

# THE HAWAIIAN PLANTERS' RECORD

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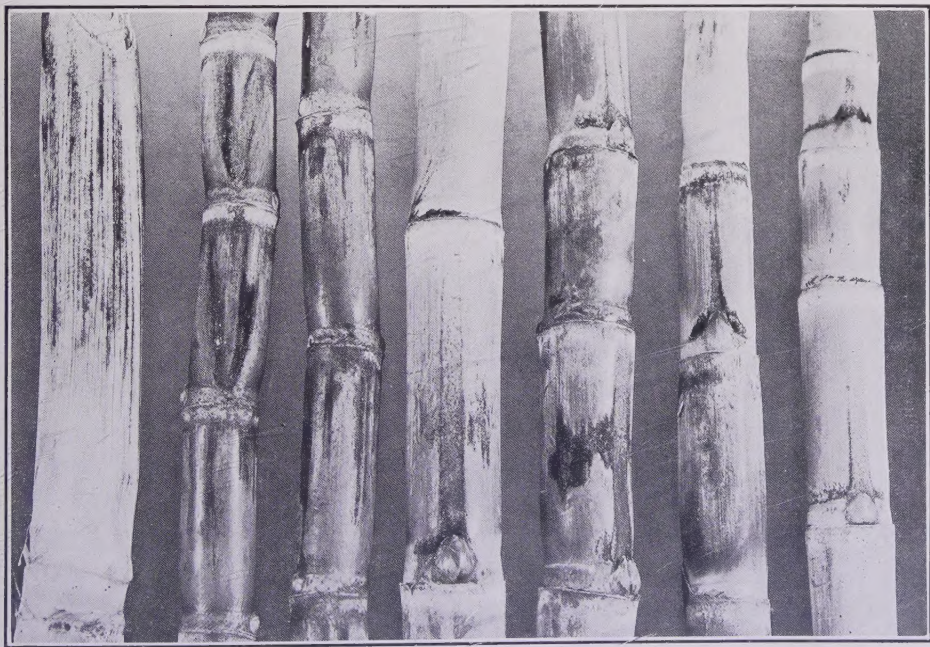
Number 2

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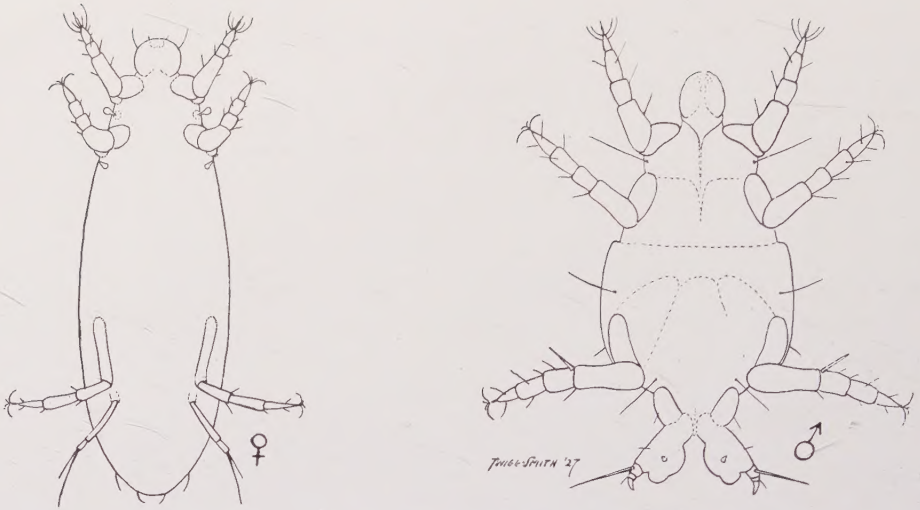
## The Java Sugar Cane Stalk Mite in Hawaii

BY O. H. SWEZEY

It is not known how long this minute mite has been in the cane fields of Hawaii. The mite itself is seldom seen, but the appearance of the cane that has been infested with mites persists indefinitely, so that their presence in a field



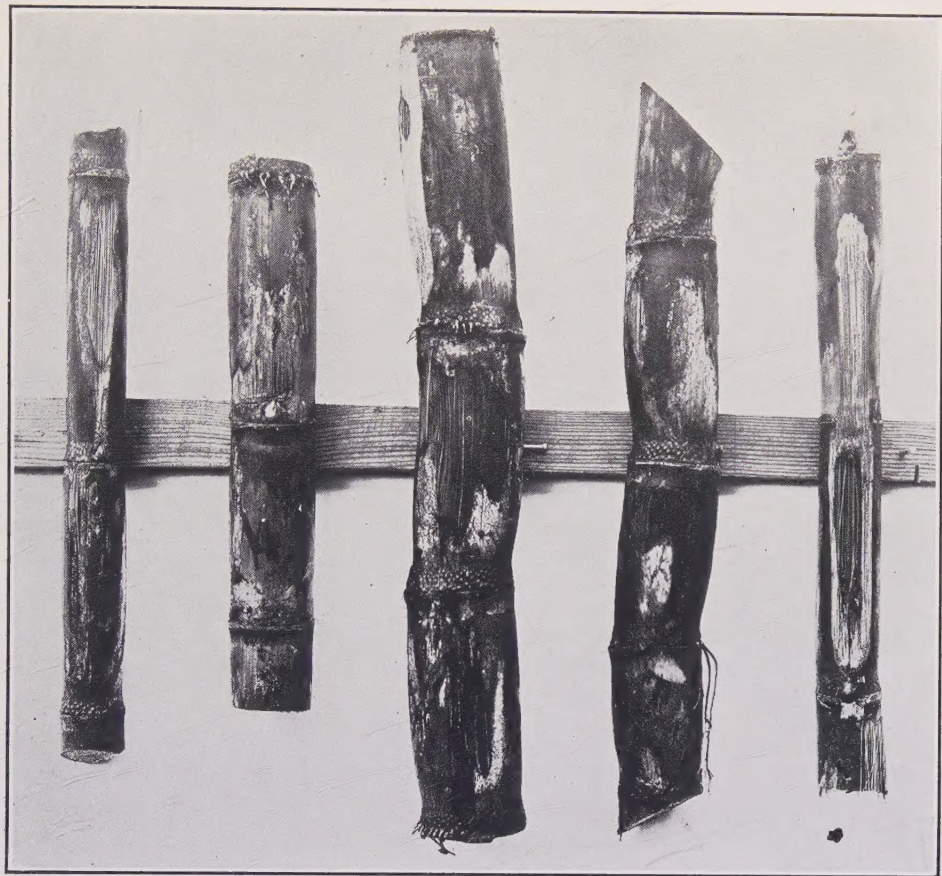
*Tarsonemus bancrofti*. The dark patches and markings on the canes are due to the rusty, dried remains of vesicles caused by the mites when the canes were soft in an earlier stage of their growth. Note that there is commonly a streak above the bud. At the extreme left are shown these same rusty streaks on the outside of a leafsheath. They sometimes occur similarly on the blade of the leaf near the base. (About half natural size.)



*Tarsonemus bancrofti*. Female mite at the left. Male mite at the right. (Both highly enlarged.)

is thereby made known. The illustration shows the characteristic appearance of a cane stalk where the mites have lived at an earlier stage in the growth of the cane. This rusty appearance of the stalk is due to the shrivelled up and dried galls that were produced when the mites were feeding there. This occurred when the stalk was very soft and still growing, closely enclosed in the green leafsheaths of the upper leaves of the stalk.

The mites are minute, microscopic white forms, and it is rather difficult to understand how they gain access to the places where found in the closely rolled leafsheaths of the growing cane spindle. By their feeding, minute globular pustules or galls are formed on the surface of the rind. It is not unusual for mites to produce abnormal growths on the plants on which they feed. There are many species that produce galls on leaves, and aborted inflorescence, or excessive growths of the flower parts may occur when fed on by the mites. The leaves of the litchi tree are sometimes affected. Examples of abnormal structures caused by mites are found on several native Hawaiian trees, as: *Broussaisia*, *Perrotettia*, *Euphorbia*, *Elaeocarpus*, etc. Often it is very difficult to associate the mites with the injury that they do, for the mites are so small and so hard to find, and often have caused or started the injury and have left it before it has advanced to the stage of being noticeable, so that when the examination is being made often no traces of them are to be found. As in the case of the sugar cane stalk mite, none is to be found in the rusty streaks of the dried remains of the galls on the stalk after these have become exposed by the falling away of the leaves. To find the mites themselves, one has to tear apart the very upper part of the cane top where the stalk is soft and still growing, and then it is difficult to find them on account of their minute size, and, too, the galls that have been formed and among which the mites are, are almost unnoticeable, being so small and colorless. They do not show up conspicuously till they become discolored in the process of drying up.



Lesions of the cane that have occurred at the areas which had been severely infested by the stalk mite.

This mite is generally distributed in Java. Some account of it is given by Kruger in "Das Zuckerrhor und seine Kultur," pp. 320, 396, Tafel IX, Fig. 3, 1899, and by Van Deventer in "Handboek voor de Suikerriet-Cultur en de Rietsuiker-Fabricage op Java," Tweede Deel, pp. 292-293, Plate 40, Fig. 7, 1906. The name given is *Tarsonymus bancrofti* Michael. It is presumed that what we have in the cane fields in Hawaii is the same species on account of the similarity of the affected cane stalks. The mites themselves have not been compared. It is known in Queensland, Mauritius, Barbados, and, no doubt, occurs on cane throughout the Pacific area, though records are not at hand.

In Porto Rico a different species occurs, *Tarsonemus spinipes* Hirst, and called the cane rust-mite by Smyth (Porto Rico Department of Agriculture Journal, 3; 4, p. 92, 1919). This is unquestionably not the species we have in Hawaii, for it is said to occur especially on Yellow Caledonia cane (Wolcott, Journ. Dept. Agr. Porto Rico, V, No. II, p. 10, 1921), whereas the stalk mite here in Hawaii is seldom found on this variety of cane. Apparently nearly all other varieties are susceptible to its attack.

Usually no appreciable injury is caused by this mite in Hawaii, though its excessive prevalence at times would indicate that there must be some check to the full growth of the cane. Instead of merely a rusty streak on the stalk extending upward from the bud and reaching to, or nearly to the next node, sometimes there are others of these rusty streaks more or less all around the stalk, and also areas continuous around the stalk at the nodes. There may also be similar rusty streaks on the leafsheaths and even on the blade of the leaf.

There have been instances where splitting of the cane stalk has occurred at the rusty streaks above the eyes, and sometimes accompanied by rotting of the stalk at this place. These have been infrequent, however, and occurring when other causes or conditions contributed in bringing about the damage. (See illustration.)

The fact that this mite is so generally and continuously spread in Hawaiian cane fields, suggests that it must be carried on the seed. This could readily be accounted for by the fact that the general practice is to use the top cutting from the stalk for planting. This would be just where there would likely be some of the mites lurking about the uppermost nodes, or eyes, or beneath any portion of leafsheath that might remain. In general, since there is no important injury done, there is no need to try to control this pest. It is reported that in Queensland, dilute carbolic acid and also lime water have been used for disinfecting the cuttings, but probably this practice is not much used.

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## The Bad Effect of Leaf Pruning Upon the Growth of Stalk and Root of Sugar Cane

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BY F. MUIR AND R. H. VAN ZWALUWENBURG

In the study of root rot in sugar cane it has been necessary to separate the various factors which inhibit the growth of roots or cause their decay after their growth. Among these factors is the pruning of the leaves, either by artificial cutting of the leaves or by death caused by insect or fungus attack. The bad effect of such pruning upon the growth of the stalk has long been recognized but its effect upon the roots has not been given so much attention, although it is equally marked. The bad effect was to be anticipated as the reduction of leaf surface reduces the amount of the manufactured substances necessary for the building up of roots and stalks. Figs. 1 and 2 illustrate the effect very plainly.

The cane was planted at Alexander Street, June 25, 1926, from three sticks of H 109 cut from one stool. The seed pieces used were of approximate length and diameter. The rows received usual irrigation, but no fertilization. After three months one-half of the row was leaf pruned, leaving only the two uppermost leaves; this pruning was repeated thereafter at intervals averaging about twelve days. The canes were harvested and the accompanying illustrations were



Fig. 1. 1, 2 and 3 are three stools of plant H 109 eight months old which were leaf pruned from the third month of growth at intervals of about twelve days. 4 is a stool of plant H 109 of same age that was not leaf pruned.

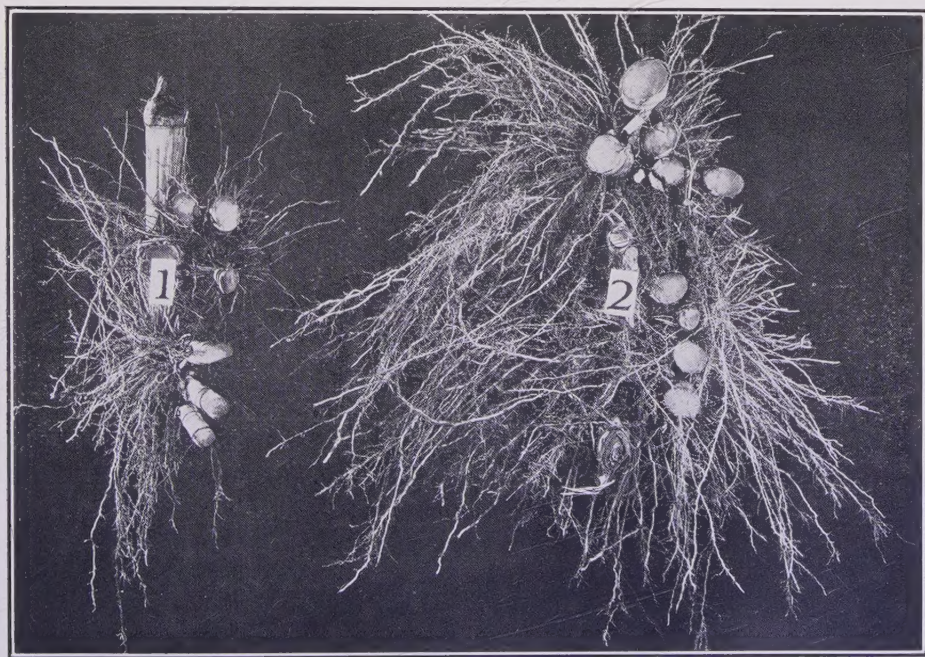


Fig. 2. 1. The root of stool No. 1 in Fig. 1. 2. The root of an unpruned stool.

taken February 4, 1927. At no time during the experiment were leafhoppers numerous, or was any leaf disease noticed.

During severe leafhopper attacks in the past it was noticed that the plants often had a poor root system and it was suggested that the plants were naturally weak on this account and therefore more susceptible to leafhopper attack than they would be if in a healthy condition. From the above experiment it is more likely that the roots were reduced by the death of the leaves due to leafhopper attack. Again, it was noticed that plant cane badly attacked by leafhopper gave poor ratoons even when the ratoons were not attacked. This is also understandable when we compare the stools in Fig. 2.

A similar condition is sometimes found to exist during bad eye spot attack, and here again it is suggested that a weak root system predisposes the plant to the fungus attack. We would suggest the reverse of this, as in the case of leafhopper attack.

The experiment will be continued on the ratoons.

## The Effect of Heat on the Germination of Sugar Cane Cuttings

By J. A. VERRET

The object of this experiment was to determine the temperature which gives the best germination of sugar cane cuttings.

Electric ovens and the constant temperature room in the sugar technology building were used to obtain the desired temperatures.

Three three-eye cuttings were placed in large Petrie dishes and covered with soil. Water was then added to bring the soil moisture to 30 per cent on the dry basis.

The results obtained from this test are tabulated herewith:

Temperature	No. of eyes planted	GERMINATION RATE								Per cent ger- minations	Avg. height of shoots on ninth day
		Days after planting							Total ger- minations		
68° F.	18*	3	4	5	6	7	8	9	..	..	0 c.m.
82° F.	36	..	3	..	3	5	4	4	19	53	4 c.m.
90° F.	18	..	..	..	..	..	3	2	5	28	5.5 c.m.
93° F.	18	1	3	5	2	..	..	..	11	61	9.0 c.m.
97° F.	54	1	9	5	14	3	..	1	33	61	11.0 c.m.
100° F.	18	..	..	6	5	1	..	..	12	67	10.5 c.m.
111° F.	18	..	4	..	..	..	..	..	4	22	4.5 c.m.

These data indicate that 68° F. is too cold and germination is greatly retarded, while 111° F. is too warm for good results.

The best temperature for rapid and high generation would seem to be between 92 to 100° F.

\* No germinations until the sixteenth day.

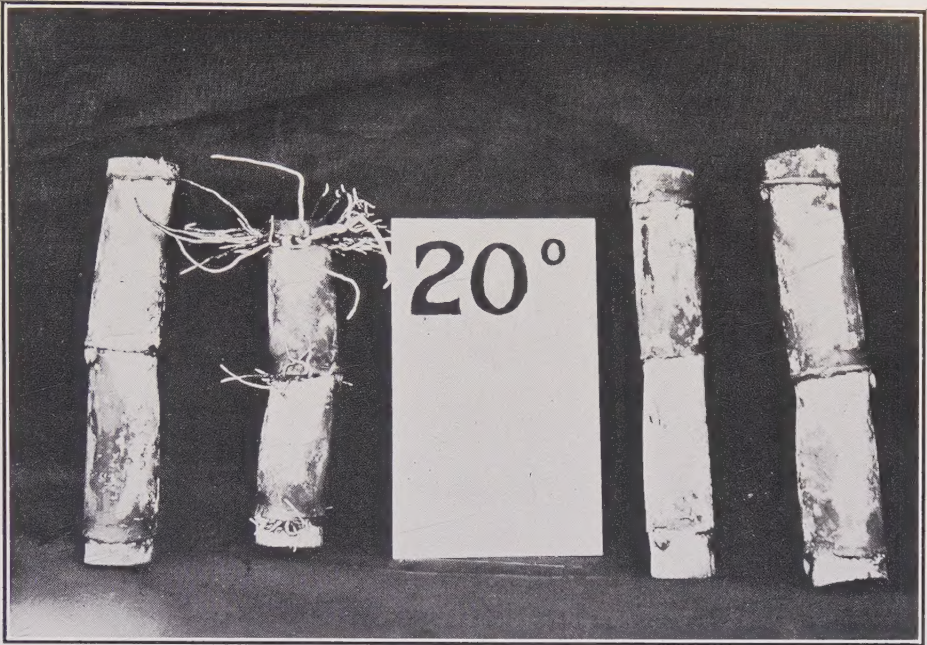


Fig. 1. These seed pieces were kept at a temperature of 68° F. Photographed sixteen days after planting. Compare with Figs. 3 and 4, and note the difference in growth.

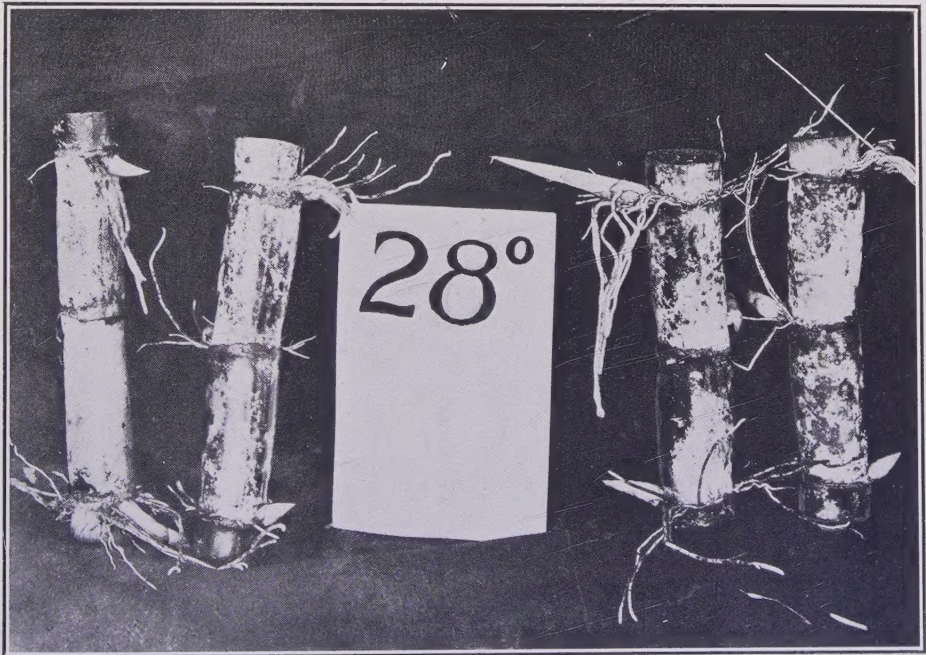


Fig. 2. Seed pieces kept at a temperature of 82° F. Photographed nine days after planting.

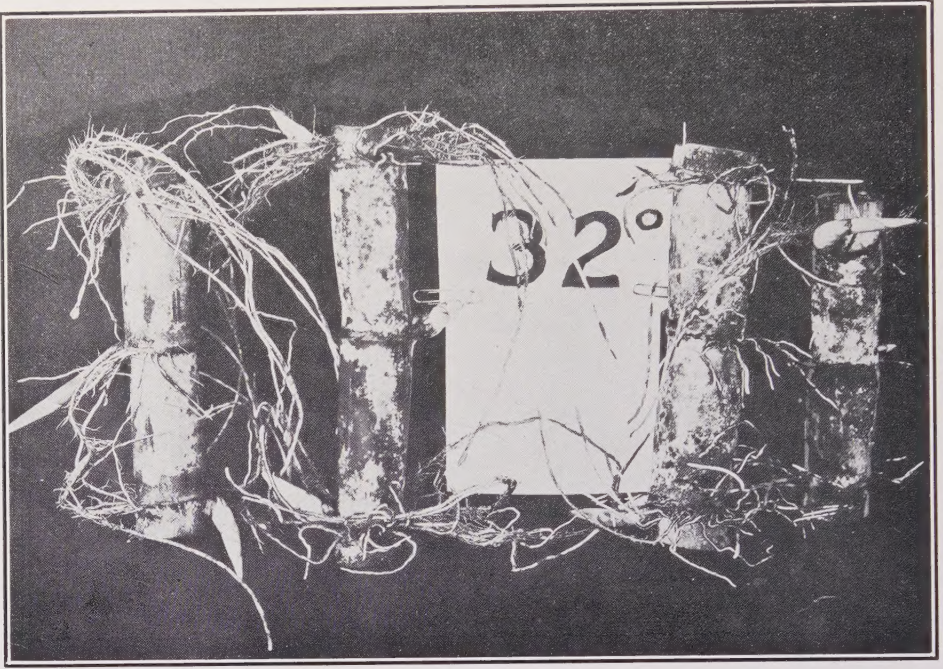


Fig. 3. Seed pieces were kept at a temperature of 90° F. Photographed nine days after planting.

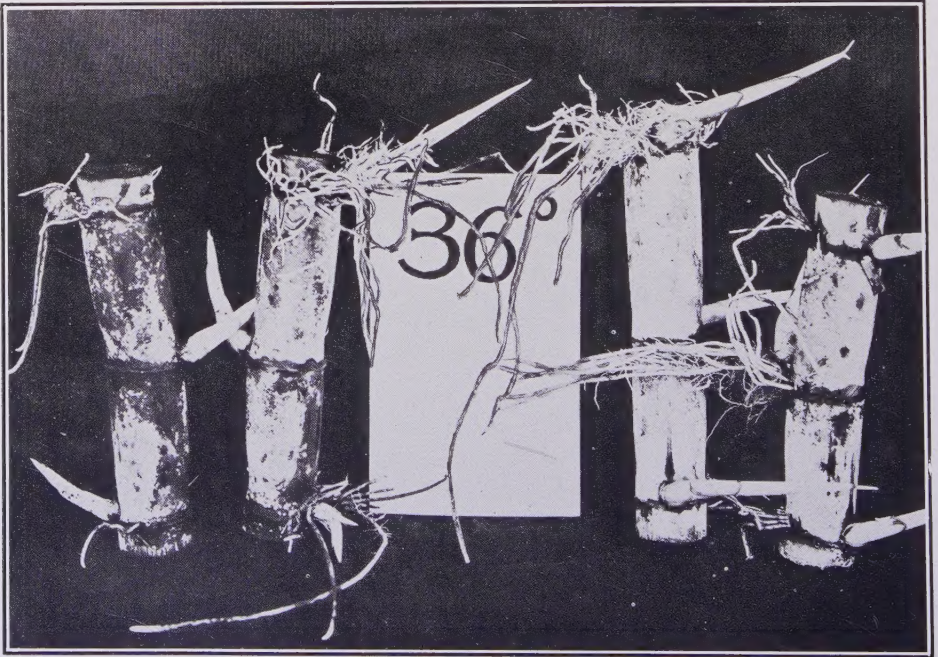


Fig. 4. These seed pieces were kept at a temperature of 97° F. Photographed nine days after planting.

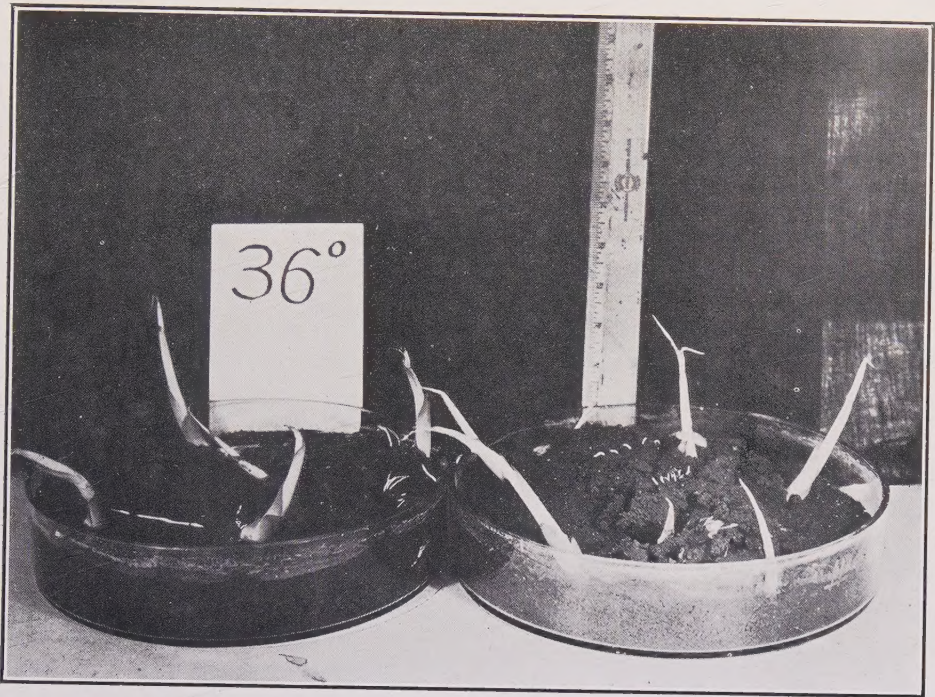


Fig. 5. Same as Fig. 4.

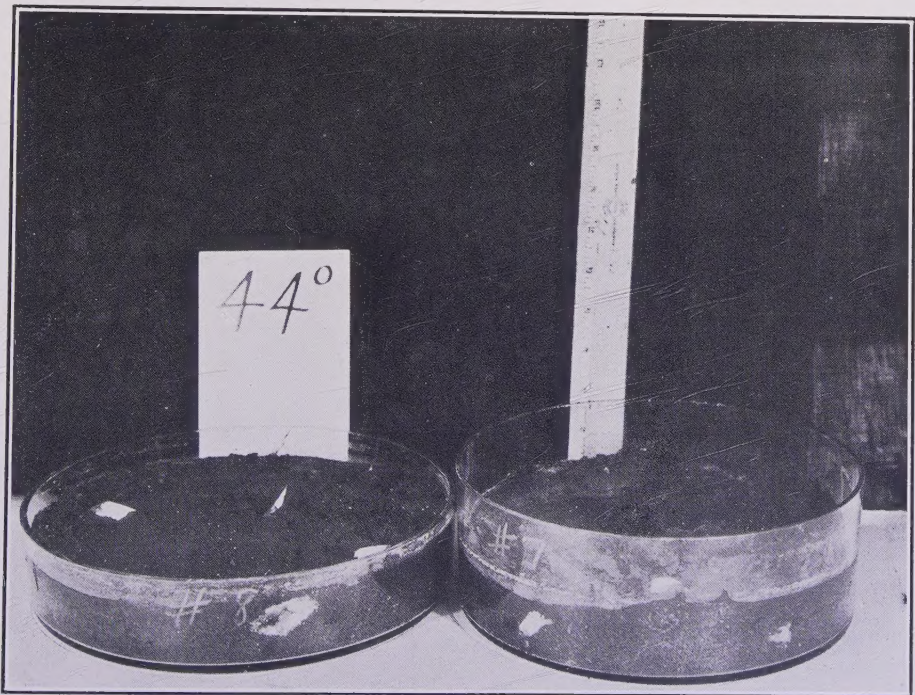


Fig. 6. Seed kept at a temperature of  $111^{\circ}$  F. Note the lack of growth as compared with Figs. 3, 4 and 5.

## The Effect of Sunlight on Cane Growth

BY J. A. VERRET AND R. H. McLENNAN

This experiment was started under the supervision of Douglas A. Cooke. Upon leaving to continue his studies in Germany the work was transferred to R. H. McLennan.

The object of this experiment was to determine the effect of varying amounts of light on the growth and development of the sugar cane plant.

The plants were in 16" concrete pots. Twenty-four pots were used divided into 8 sets of 3 pots each. All treatments, such as irrigation, fertilization, etc., except light, were uniform to all pots.

The soil mixture used was made up of 5 parts well rotted cane leaf compost, 4 parts Makiki soil and 1 part of black sand. A three-eye cutting of H 109 from which the two end eyes had been gouged out, was planted in each pot. A large number of these seed pieces had been previously germinated in small trays. These seed pieces were as nearly alike in size and age as it was possible to make them and plants of exactly the same size were selected for planting in the pots.

Five sets of pots were kept continually covered with dark, thick, fairly thick, thin and very thin cages. The dark cage was made of roofing paper and all precautions taken to prevent entrance of light. The other four cages were covered with varying thicknesses of cloth. Of the other three sets, one was exposed to eight hours of sunlight, another to four hours, the rest of the time they were covered with dark cages; the third set was exposed for the entire twenty-four hours.

The set receiving eight hours sunlight was exposed from 8:00 a. m. to 4:00 p. m. The four-hour one from 8:00 a. m. to noon.

Weekly counts and measurements were made for six weeks.

The per cent of light admitted to the various cages was determined by exposing blue print paper to full sunlight, and in the cages, and noting the rate of change.

The data obtained are tabulated as follows:

Treatment	Per cent illumination	Total elongation for all shoots in inches	Total new shoots	Average temperature
Check .....	100	206	25	30.3
Exposed 8 hours.....	...	178	18	...
Very thin .....	42	173	12	31.8
Thin .....	12.7	88	6	32.3
Fairly thick .....	4	37	3	32.2
Exposed 4 hours.....	...	26	3	...
Thick .....	Less than 1	8	0	31.3
Dark .....	Less than 1	6*	0	31.2

\* The plant in one pot died at the end of four weeks. The plants in the other two pots were dying when the experiment stopped. (See Fig. 8.)

These data conclusively show that any lessening in normal illumination is detrimental to maximum sugar cane growth in June and July.

This is well shown in the illustrations, Figs. 1 to 8. The full sunlight canes had thicker stalks and broader, greener leaves, and the best stooling (Fig. 1). Next in order were the plants exposed to full sunlight from 8:00 a. m. to 4:00 p. m. (Fig. 2). In this set the leaves were not quite as sturdy as were the full sunlight ones.

In Fig. 3 is shown the set of plants which received 42 per cent of light, but no direct sunlight, as they were continually covered with a cage made of very thin muslin. This would about correspond to the light of a fairly cloudy day. Here we see at once a change in the character of growth. The plants tend to become long and slender. The leaves are thin and narrow with a distinct yellow color as compared to the dark green of the plants shown in Figs. 1 and 2.

In Fig. 4 we show the plants receiving 12.5 per cent of light coming through thin sheeting. Note how weak the leaves are from their broken condition, and the very poor stooling.

In the remaining sets there was practically no stooling and all the plants were very weak.



Fig. 1. These pots were entirely exposed. Note the stunting that results from the normal supply of sunlight.



Fig. 2. The pots in this picture were exposed to sunlight daily for a period of eight hours from 8 a. m. to 4 p. m. A dark cage covers them from 4 p. m. to 8 a. m. This cage admits less than 1 per cent normal daylight. Compare stunting qualities with Fig. 1.



Fig. 3. These pots were covered day and night with a cage that admitted 41.67 per cent of normal illumination. Note the shoots and compare them with those in Fig. 1.



Fig. 4. A cage that admitted 12.50 per cent of normal illumination covers these three pots day and night. It would be well to note shoots in Figs. 1 and 3 and compare them.



Fig. 5. These pots were exposed daily to sunlight from 8 a. m. to 12 noon. The rest of the time they were covered with a dark cage, as in Fig. 2. Compare stooling qualities with Figs. 1 and 2.



Fig. 6. These plants get 4.17 per cent of the normal daylight through the cage that covers them. Due to the lack of sunlight, very few shoots have grown. Note the stooling in the other pots, where more light is admitted.



Fig. 7. These plants received less than 1 per cent normal daylight, but more light than the pots in Fig. 8. Note the type of shoots developed due to the lack of light.



Fig. 8. The dark cage that covered these plants allowed less than 1 per cent of normal daylight to reach the plants. Compare this with Fig. 7. Note the droopy appearance of the leaves, due to the lack of photosynthesis taking place.

## Early Fertilization Gives Better Juices

PIONEER MILL COMPANY EXPERIMENT 56

BY J. A. VERRET

The cane in this field was H 109, first ratoons, 21 months old when harvested on January 6, 1927.

The layout of this experiment comprised 28 watercourse plots of varying areas, each approximating 0.1 acre. We had seven repetitions of each treatment.

The fertilizer applications to these plots were as follows:

Plots	No. of Plots	June 1925	Sept., 1925		Nov. 1925		Feb. 1926	April 1926	Totals		
		Amm. Sul.	Amm. Sul.	Acid Phos. Sul.	Pot. Sul.	Amm. Sul.	N. S.	N. S.	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
N	7	250	335	750	204	...	774	...	240	150	100
O	7	250	335	750	204	385	...	...	240	150	100
P	7	250	43	750	204	293	...	774	240	150	100
Q	7	250	335	750	204	293	...	387	240	150	100

The results obtained are given:

### Treatment—Pounds Nitrogen

Plots	June 1925	Sept. 1925	Nov. 1925	Feb. 1926	April 1926	Tons per Acre		
						Cane	Q. R.	Sugar
O	50	70	120	0	0	77.3	8.31	9.08
N	50	70	...	120	0	74.7	8.74	8.54
Q	50	70	60	0	60	73.8	8.72	8.46
P	50	70	60	0	120	71.8	8.81	8.15

In this test the highest yields and the best juices were from the plots getting the earliest fertilization, while the lowest yields and the poorest juices were from the late fertilizer plots. The plots which received the "spring dressing" in November produced half a ton of sugar more than the plots receiving it four months later in February, and almost one more when this application was delayed to April.

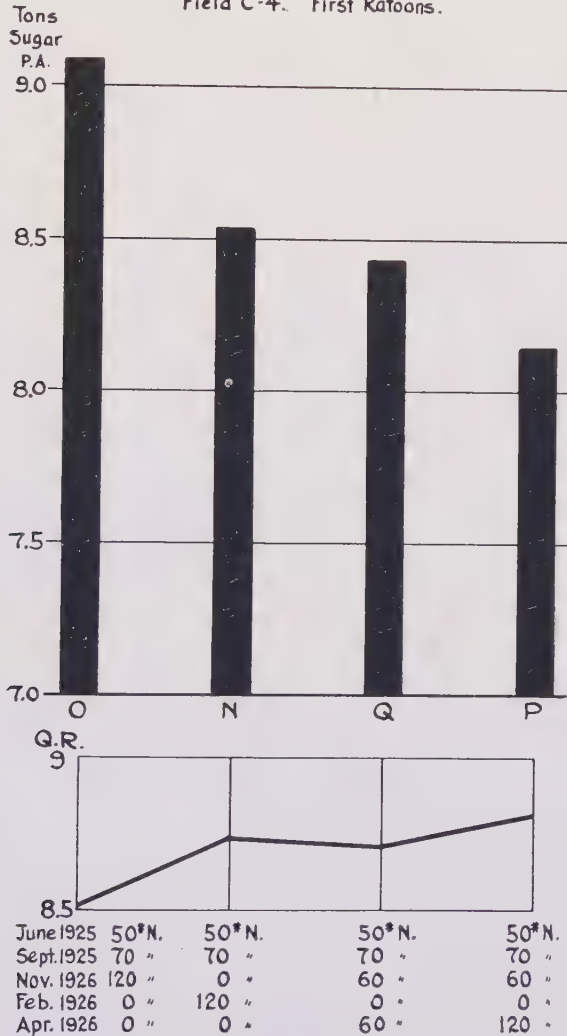
The yields show a gradual, steady decrease as fertilization is delayed, while the juices show the same steady decrease in quality.

We are very strongly convinced that we can very materially improve our juices and increase our yields of sugar by early, intensive fertilization. This means applying all the fertilizer within six months. By this system all fields harvested up to July would receive all their fertilization before the end of the year. This will naturally lead towards shorter cropping, as with the more intensive growth in the beginning the cane will obtain its growth more quickly than is now the case.

We also believe that this applies to the rainy districts as well as to the irrigated ones. Recent studies on the irrigated plantations show that cane up to six months receives from 4 to 6 acre inches of water per acre per irrigation. The irrigation intervals are about 20 days on an average. This amount of water is applied very rapidly and does not cover the entire surface of the ground.

The rainy districts get no such rains at 20-day intervals. So we do not believe that the plantations of heavy rainfall need fear to lose any more fertilizer than is the case on the irrigated ones. A number of experiments trying this are now being laid out along the Hilo coast.

**TIME OF APPLICATION OF NITROGEN**  
**PIONEER MILL CO. EXP. 56, 1927 CROP**  
 Field C-4. First Ratoons.



In addition to these small experimental areas we hope to have a number of large fields treated in the same manner in order that we may study the effect on the juices in a large way.

It was recently the writer's privilege to visit a large field of plant cane on the Hilo coast. This was as fine a field of cane as I have seen, and the manager is safe in talking about 100 tons per acre. But the most interesting thing about this field is that it received all its fertilizer within six months of planting.

Detailed yields by plot:

FIELD C-4—PIONEER MILL COMPANY—EXPERIMENT NO. 56—  
 “TIME OF APPLICATION OF N.”

Plot No.	Brix	Pol.	Purity	Cane total lbs.	Area	T. C. P. A.	Q. R.	T. S. P. A.
1-P	19.37	15.97	82.45	12,780	.092	69.46	8.81	7.88
5-P	19.37	15.97	82.45	14,860	.091	81.65	8.81	9.27
9-P	19.37	15.97	82.45	14,280	.098	72.86	8.81	8.27
13-P	19.37	15.97	82.45	12,590	.091	69.18	8.81	7.85
15-P	19.37	15.97	82.45	14,780	.098	75.41	8.81	8.56
19-P	19.37	15.97	82.45	13,830	.095	72.79	8.81	8.26
25-P	19.37	15.97	82.45	11,420	.093	61.40	8.81	6.97
Average.....						71.82	8.81	8.15
2-O	19.80	16.44	83.05	15,590	.090	86.61	8.51	10.18
6-O	19.80	16.44	83.05	12,790	.090	71.06	8.51	8.35
8-O	19.80	16.44	83.05	14,990	.097	77.27	8.51	9.08
12-O	19.80	16.44	83.05	14,340	.095	75.47	8.51	8.87
18-O	19.80	16.44	83.05	13,400	.093	72.04	8.51	8.46
24-O	19.80	16.44	83.05	12,810	.091	70.38	8.51	8.27
28-O	19.80	16.44	83.05	14,630	.083	88.13	8.51	10.35
Average.....						77.28	8.51	9.08
3-N	19.53	16.10	82.44	14,540	.094	77.34	8.74	8.85
7-N	19.53	16.10	82.44	10,480	.078	67.17	8.74	7.68
11-N	19.53	16.10	82.44	15,170	.095	79.84	8.74	9.13
17-N	19.53	16.10	82.44	13,470	.091	74.01	8.74	8.47
21-N	19.53	16.10	82.44	11,740	.081	72.47	8.74	8.29
23-N	19.53	16.10	82.44	12,470	.092	67.77	8.74	7.75
27-N	19.53	16.10	82.44	14,470	.086	84.13	8.74	9.62
Average.....						74.68	8.74	8.54
4-Q	19.44	16.09	82.77	12,230	.095	64.37	8.72	7.38
10-Q	19.44	16.09	82.77	16,970	.093	91.24	8.72	10.46
14-Q	19.44	16.09	82.77	14,180	.098	72.35	8.72	8.30
16-Q	19.44	16.09	82.77	14,380	.092	78.15	8.72	8.96
20-Q	19.44	16.09	82.77	12,670	.086	73.66	8.72	8.45
22-Q	19.44	16.09	82.77	12,980	.098	66.22	8.72	7.59
26-Q	19.44	16.09	82.77	13,390	.095	70.47	8.72	8.08
Average.....						73.78	8.72	8.46

# The Cause of Sectional Chlorosis of Sugar Cane

BY FREDERICK C. NEWCOMBE AND H. ATHERTON LEE

The name sectional chlorosis was first used by W. P. Naquin, manager of the Honokaa Sugar Company, to designate a white horizontal marking or banding of sugar cane leaves; the white marking usually extended completely across the



Fig. 1. A cane top of the variety H 109 from Waianae, showing the whitened sections of the leaves known as sectional chlorosis. The occurrence of these chlorotic sections near the base of the oldest leaf, and higher up on each succeeding younger leaf, is explained by the synchronous occurrence of the injury to all leaves when they were closely wrapped together in the central cylinder or spindle.

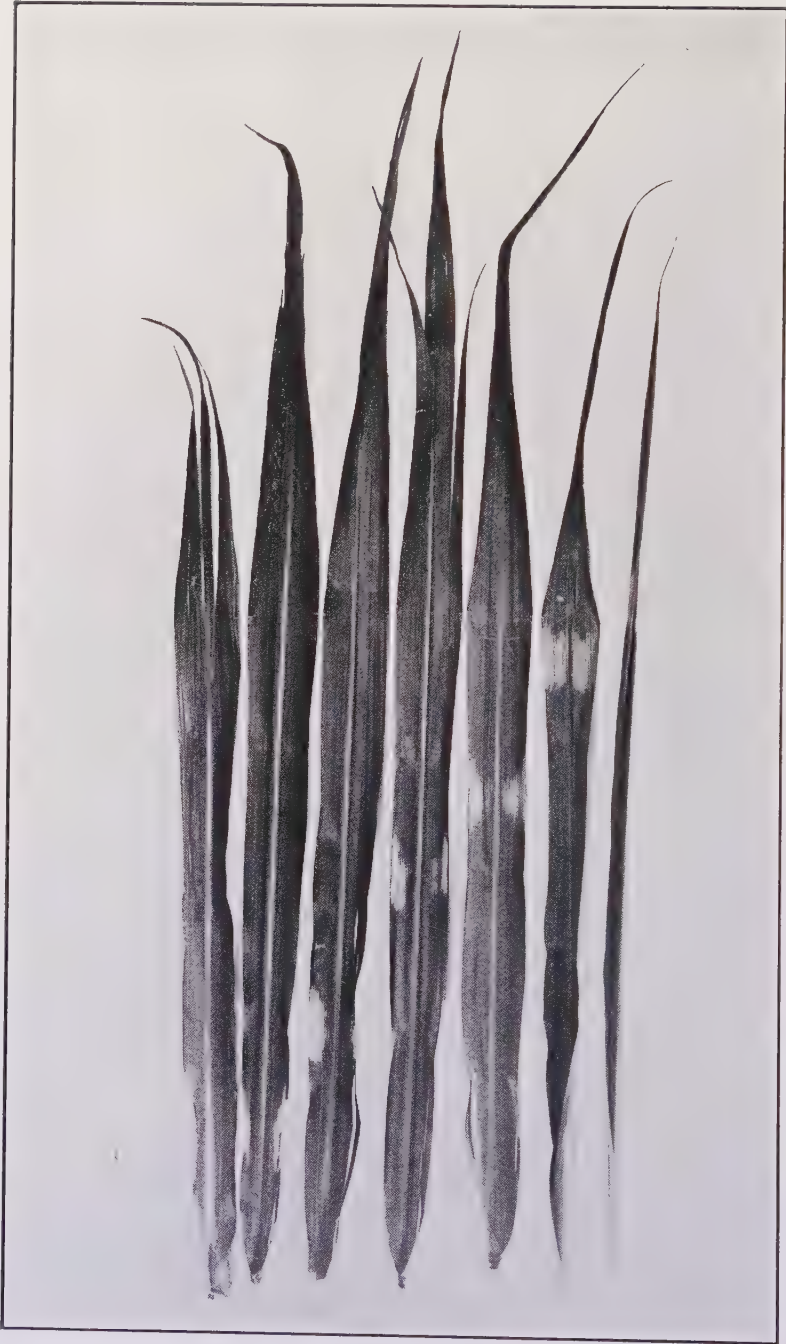


Fig. 2. Leaves of a cane stalk arranged in order of their age; the oldest leaves at the left and the youngest at the right. As in the case of the illustration in Fig. 1, the sectional chlorosis near the base of the oldest leaf, and occurring higher up on each successive younger leaf is explained by the synchronous occurrence of injury while the affected areas were contiguous to each other in the spindle or central cylinder. Injury from low temperatures in the central cylinder has reproduced this type of chlorosis experimentally.



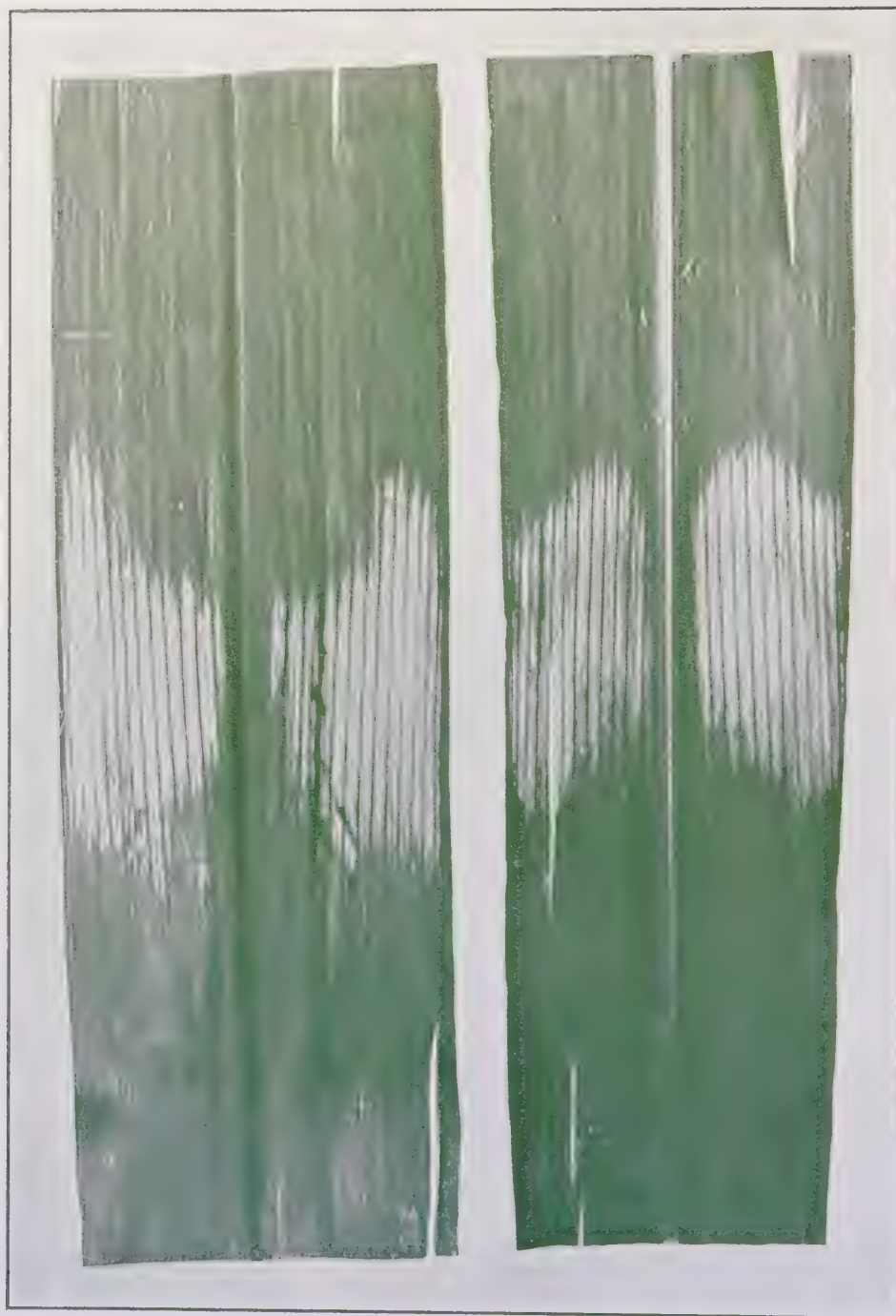


Plate 1. A colored illustration showing the nature of sectional chlorosis on leaves of H 109. This type of chlorosis can be reproduced experimentally by low temperatures at the central cylinder or spindle of the cane top.

leaf from one edge to another and varied in width from one-half inch in some cases to 3 or 4 inches in others. This marking of the leaves was observed at Honokaa and Mountain View on the island of Hawaii, and later, in March, 1924, in whole fields of H 109 at Waianae Company and on the Waianae side of Ewa Plantation Company. The appearance of this sectional chlorosis is shown in Plate 1 and in the illustrations in Figs. 1 and 2.

The injury evidently takes place in the central cylinder of the cane top as evidenced by the positions of the white markings on the leaves, since the youngest leaves show the markings near their tips, the next older leaves show the markings further down the leaf blade, and the oldest leaves show the markings near the bases of the blades. If the injury occurred to all these leaves at one time, then the leaves must have had the positions of the markings contiguous to one another, which must therefore have occurred in the spindle or central cylinder.

No serious injury resulted to the cane at the time and the affected leaves matured and were replaced by unaffected normal leaves. The cause of this uniform marking on all plants in a field, however, occasioned considerable interest. In the cases of sectional chlorosis at Waianae and Ewa, there were in some fields two blanched areas to a leaf and the time of origin of these areas seemed to coincide closely with the occurrence of two kona storms. Theories were advanced that the marking resulted from salt spray blown from the sea, during these storms, which washed into the central cylinders of the cane. Also the theory was advanced that the chlorosis resulted from water at low temperatures lying in the central cylinders of the cane for long periods.

An experiment was tried here in Hawaii later in the year 1924 in which ice-cooled water was allowed to run from a bucket into the central cylinder of the cane for a period of three days, but no chlorosis resulted.

Faris\*, an investigator in Cuba, however, formed an inverted cone of paper around the spindle of the cane, and placed cracked ice in the cone for three successive nights; eight to ten days later the sectional chlorosis appeared on the young cane leaves coming from the central cylinder. He found the varieties H 109 and D 1135 especially susceptible, while from field observations he found Badila, P. O. J. Nos. 36, 213, 234, 979, 2714, Kassoer Uba and Cristalina to be resistant. His observations led to the opinion that cane which was in an actively growing, succulent condition was more susceptible than slow-growing cane with hardened leaves.

In order to confirm the results of Faris, his methods were duplicated here in Hawaii. On the nights of January 15th, 16th and 17th, 1927, starting at 5:00 p. m., cracked ice was placed in inverted cones of Manila paper tied around the sugar cane stem just below the spindles of the cane. Ten stalks of H 109 were treated with ice in this way, while untreated stalks in the same stools were left as controls. The ice was maintained throughout each night, but no effort was made to keep the cones filled with ice throughout the day. Usually, however, small amounts of ice remained in the cones until 10:00 or 11:00 o'clock of the

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\* Faris, James A. Cold chlorosis of sugar cane. *Phytopathology*, Vol. 16, No. 11, Nov., 1926, p. 885.

following morning, while on the last day, the weather being cloudy, the ice did not melt completely in some cones until late in the afternoon.

The water from the melted ice was allowed to run out through the lower tips of the cones and usually ran off down the stems; however, a considerable part of the time, standing water of low temperature must have rested in the central cylinders of the cane also from the gradual melting of the ice.

On January 24th, chlorotic areas were evident on the newest emerged leaves of the treated canes, which were typical of sectional chlorosis as it occurs naturally. Untreated canes in the same stools with the treated canes were unaffected and normal.

The experiment indicated clearly that sectional chlorosis could be caused by low temperatures at the spindle of the cane. One would not be warranted in concluding, however, that low temperatures are the cause of all cases of sectional chlorosis, but the foregoing experiments will explain many of the occurrences of this peculiar marking.

Although we used ice in these experiments, air diffusion and the insulation of cane leaves would cause the temperature in the growing point to be considerably above ice temperatures of 32° F., possibly the temperatures inside the central cylinder would be 40 or 42° F.

The coldest temperatures at Waianae and Ewa for the winter of 1923-1924 occurred on January 16th, when 50° F. was recorded at Ewa, and on January 18th, when 55° F. was recorded at Waianae. Mr. Voorhees, in charge of the station of the U. S. Weather Bureau in Honolulu, stated that these temperatures were recorded in weather instrument shelters and on a still night would be several degrees higher than the air in an open cane field.

A report of a publication by the United States Weather Bureau summarized by J. W. Smith\* shows that leaf temperatures at night may be 9 to 10° F. below atmospheric temperatures. This being the case, atmospheric temperatures of 50 to 55° F. in instrument shelters would result in leaf temperatures well within the range in which we reproduced this sectional chlorosis. The condition of the cane undoubtedly has also an influence on the occurrence of this sectional chlorosis.

Sectional chlorosis has never caused serious loss, but with the present understanding of its cause there is still less reason to feel concern where it occurs.

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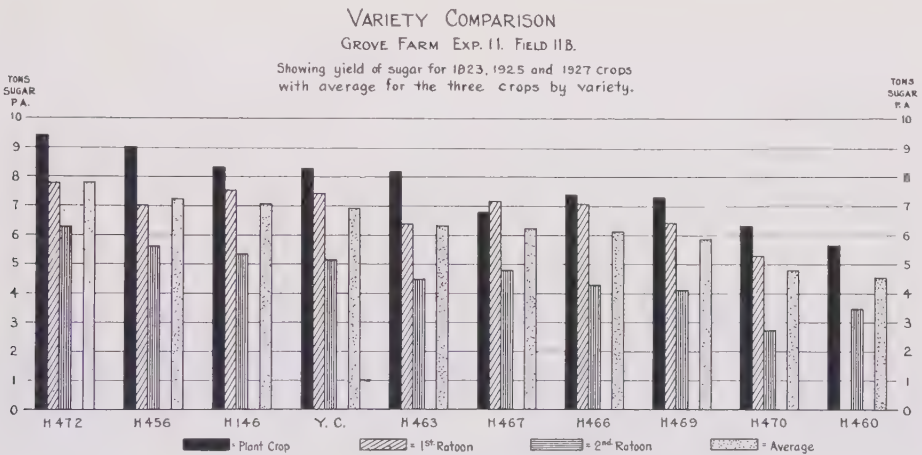
\* *Agricultural Meteorology*. The MacMillan Co., 1920, p. 75.

## Variety Test

### GROVE FARM EXPERIMENT 11\*, 1923, 1925, 1927 CROPS

This experiment compares the standard variety of cane, Yellow Caledonia, with a number of the H 400 seedlings.

This test was in Field 11B, irrigated and of medium elevation. Three crops have been harvested, plant, first ratoon and second ratoon.



The results are given in the following table:

### GROVE FARM COMPANY, LTD., EXPERIMENT 11, 1927 CROP

January 8, 1927

Variety Experiment—Field 11B

Harvesting results of plant, first and second ratoons

Varieties arranged in their order of yield

Variety	Crop	Brix	Pol.	Pur.	Q. R.	T. C. P. A.	T. S. P. A.	Average 3 crops	
								T. C. P. A.	T. S. P. A.
H 472	Plant ..	16.88	14.74	87.3	9.02	85.33	9.42		
	1st Rat.	18.20	15.57	85.5	8.58	60.75	7.80	67.02	7.84
	2nd Rat.	17.70	15.48	87.5	8.70	54.98	6.31		
H 456	Plant ..	18.00	15.79	87.7	8.39	73.98	9.06		
	1st Rat.	17.27	15.38	89.1	8.54	60.36	7.07	59.64	7.25
	2nd Rat.	18.10	16.51	91.2	7.90	44.58	5.64		
H 146	Plant ..	17.82	15.85	88.9	8.27	69.27	8.38		
	1st Rat.	18.55	16.80	90.6	7.77	58.96	7.59	57.09	7.11
	2nd Rat.	18.40	16.53	89.9	8.00	43.05	5.38		

\* Experiment planned and laid out by John H. Midkiff. Experiment harvested, plant and first ratoon, by O. C. Markwell; second ratoon by Raymond Conant.

Variety	Crop	Brix	Pol.	Pur.	Q. R.	T. C. P. A.	T. S. P. A.	Average 3 crops	
								T. C. P. A.	T. S. P. A.
Y. C.	Plant ..	17.67	15.18	86.2	8.78	73.10	8.32		
	1st Rat.	18.67	16.75	89.7	8.71	58.54	7.49	59.68	6.98
	2nd Rat.	17.70	15.04	85.0	9.20	47.40	5.15		
H 463	Plant ..	17.35	15.42	88.9	8.54	70.14	8.21		
	1st Rat.	17.10	15.90	88.2	8.75	56.12	6.41	54.78	6.38
	2nd Rat.	18.10	15.88	87.8	8.40	38.10	4.52		
H 467	Plant ..	16.30	13.74	84.3	9.84	67.12	6.82		
	1st Rat.	18.30	16.45	89.9	7.97	57.28	7.19	55.96	6.28
	2nd Rat.	17.80	15.16	85.2	9.00	43.48	4.83		
H 466	Plant ..	16.89	14.76	87.4	8.96	66.46	7.42		
	1st Rat.	18.40	16.31	88.6	8.09	57.49	7.11	55.08	6.17
	2nd Rat.	16.80	14.32	85.2	9.60	41.31	4.30		
H 469	Plant ..	16.70	14.26	85.4	9.38	67.27	7.17		
	1st Rat.	17.70	15.40	87.0	8.63	55.53	6.43	54.56	5.92
	2nd Rat.	17.20	14.32	83.2	9.80	40.88	4.17		
H 470	Plant ..	17.67	15.32	86.7	8.71	55.60	6.37		
	1st Rat.	17.80	15.59	87.6	8.49	45.70	5.31	43.95	4.81
	2nd Rat.	16.10	12.93	80.3	11.10	30.56	2.75		
H 460	Plant ..	15.95	13.48	84.5	10.00	56.55	5.66		
	1st Rat.	No Sample				50.17	...	48.18	4.58
	2nd Rat.	16.20	13.17	81.3	10.80	37.82	3.50		

An average of the three crops shows that H 472, H 456 and H 146 have given better yields than the Yellow Caledonia checks. As these canes are much more resistant to eye spot than H 109, it should be worth while to plant them in bad eye spot areas.

These canes probably require a little more care at the start of a crop as they are inclined to be weak ratooners.

H 456 has averaged better juices than either H 472 or Yellow Caledonia. This cane is being spread on three of the plantations on Kauai. There are almost 300 acres of H 456 planted for the 1928 crop on Kauai. Yellow Caledonia and H 146 had less rotten cane in the plant crop than any of the others. H 472 had some damaged cane in the plant crop.

The two poorest canes, H 470 and H 460, were badly rotted in all three crops.

TABLE SHOWING TOTAL CANE AND SUGAR FOR THE THREE CROPS BY VARIETY ARRANGED IN ORDER OF THEIR SUGAR YIELD

Variety	Total cane per acre for 3 crops	Total sugar per acre for 3 crops	Gain or loss of varieties over Yellow Caledonia	
			cane	sugar
H 472 .....	201.06	23.53	+22.02	+2.57
H 456 .....	178.92	21.77	— .12	+ .81
H 146 .....	171.28	21.35	— 7.76	+ .39
Y. C. ....	179.04	20.96	0.00	0.00
H 463 .....	164.36	19.14	—14.68	— .82
H 467 .....	167.88	18.84	—11.16	—2.12
H 466 .....	165.26	18.83	—13.78	—2.13
H 469 .....	163.68	17.77	—15.36	—3.19
H 470 .....	131.86	14.43	—47.18	—6.53
H 460 .....	144.54	9.16	—34.50	—11.80*

\* Omitted from graph—sugar yield on 2 crops only.

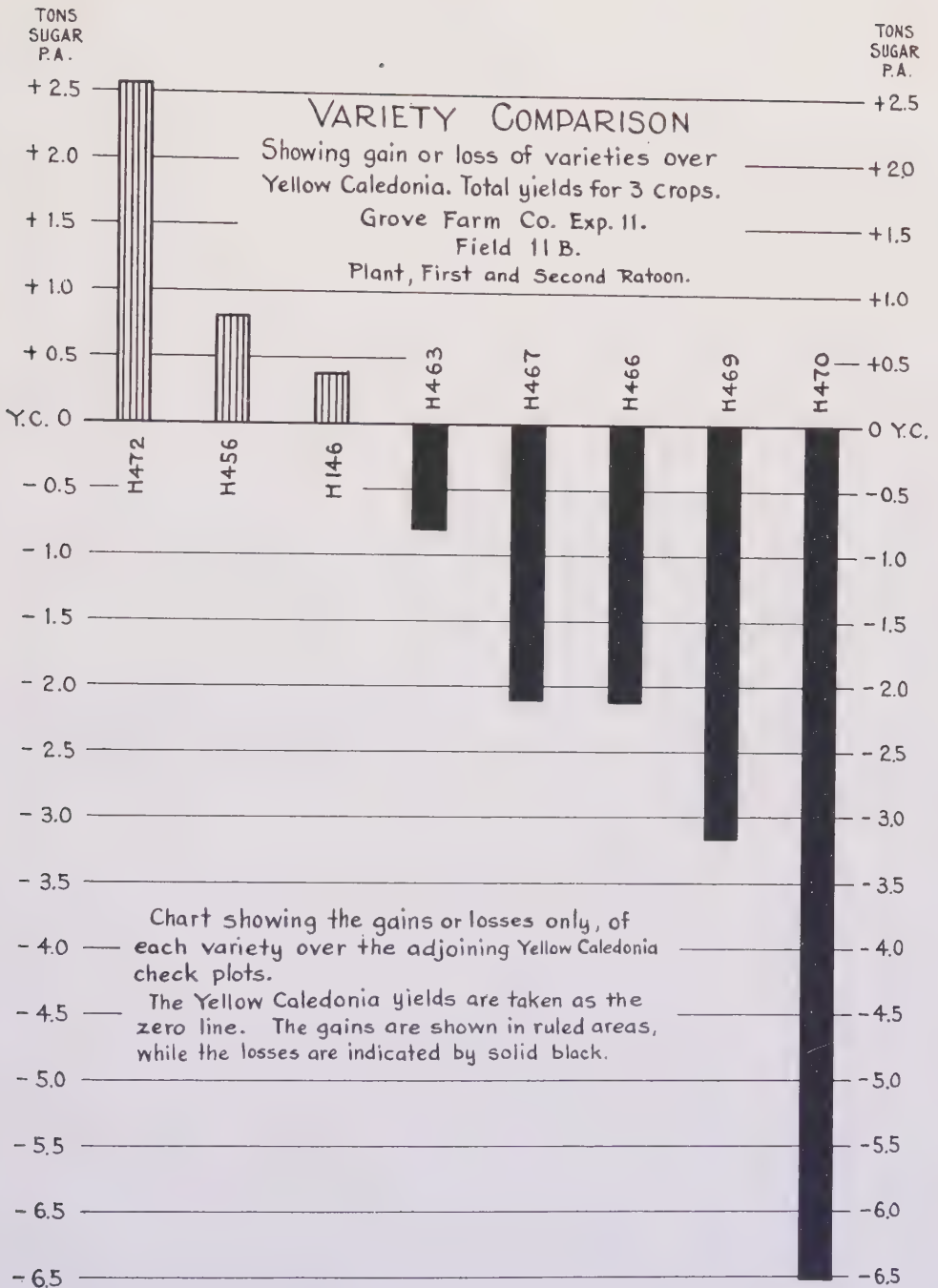


Fig. 2.

## DETAILS OF EXPERIMENT

- Object:** To compare H 146 and a number of H 400 seedlings with Yellow Caledonia at Grove Farm.
- Location:** Field 11B.
- Crop:** Plant, first ratoons, second ratoons.
- Layout:** Number of plots, 104. Size of plots, 1/10 of an acre, 50' x 87'; consisting of 18 straight lines each 50' x 4.84'. Twenty of these plots are 1/20 of an acre, each consisting of 9 straight lines.
- Fertilization:** Uniform to all plots.
- Progress:** July 7-14, 1921—Seed cut and planted.  
 March, 1923—Plant crop harvested.  
 June, 1923—Cane cut back.  
 February 18-25, 1925—First ratoon crop harvested.  
 January 8-13, 1927—Second ratoon crop harvested.

R. E. D.

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## Amount of Nitrogen at Pioneer Mill Company

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### PIONEER MILL CO. EXPERIMENT 23\*, 1925 AND 1927 CROPS

This experiment was planned to determine the most profitable amount of nitrogen to use at Pioneer. It has been carried on for two crops, one plant and one ratoon. It is laid out in Field G2 at an elevation of 450 feet. This field is irrigated and planted to H 109 cane. In the plant crop phosphoric acid was applied to all plots at the rate of 100 pounds per acre, and potash at the rate of 50 pounds per acre. The phosphoric acid was increased to 150 pounds, and the potash to 100 pounds per acre, uniformly for all plots, for the first ratoon crop.

In this experiment the comparison is made between 137, 180, 230 and 280 pounds of nitrogen for the plant crop, and between 140, 190, 240 and 290 pounds of nitrogen per acre in the case of the first ratoon crop. The fertilizer was applied in September, 1923, January, 1924, and February, 1924, for the plant (1925) crop. The ratoons were fertilized in July, 1925, and in February, 1926. The treatments and the results obtained for the two crops are summarized in the following tables:

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\* Experiment planned by J. A. Verret. Experiment laid out by F. W. Broadbent. Experiment harvested, plant crop by F. W. Broadbent, first ratoon by D. M. L. Forbes.

## AMOUNT OF NITROGEN—SUMMARY OF RESULTS

Plant Crop—1925

Plots	No. of Plots	Treatment	T. C. P. A.	Yields Q. R.	T. S. P. A.
D	7	132 pounds Nitrogen.....	64.0	6.30	10.15
E	7	180 pounds Nitrogen.....	66.8	6.32	10.58
F	7	230 pounds Nitrogen.....	73.3	6.50	11.28
G	7	280 pounds Nitrogen.....	74.1	6.60	11.23

**NITROGEN-AMOUNT TO APPLY**  
Pioneer Mill Co. Exp. 23, 1925 crop  
Plant Cane

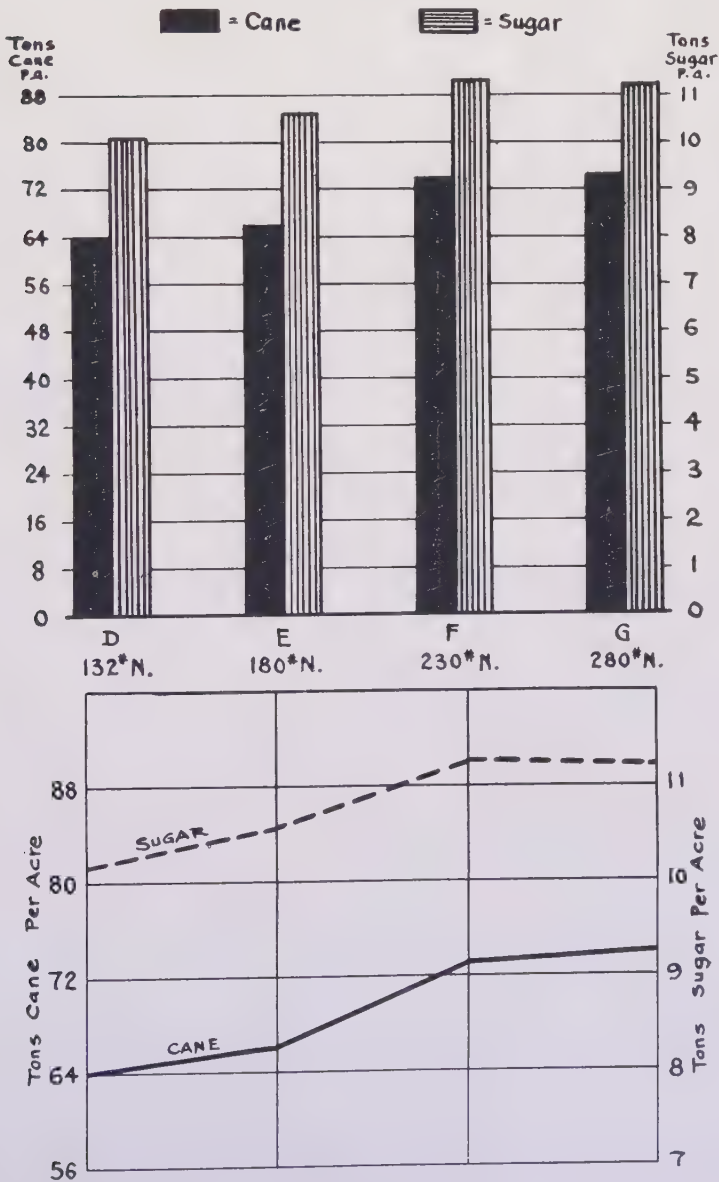


Fig. 1.

## NITROGEN - AMOUNT TO APPLY

Pioneer Mill Co. Exp. 23, 1925 Crop

Plant Crop

Curves Showing Cane Yields Per Acre By Plots.

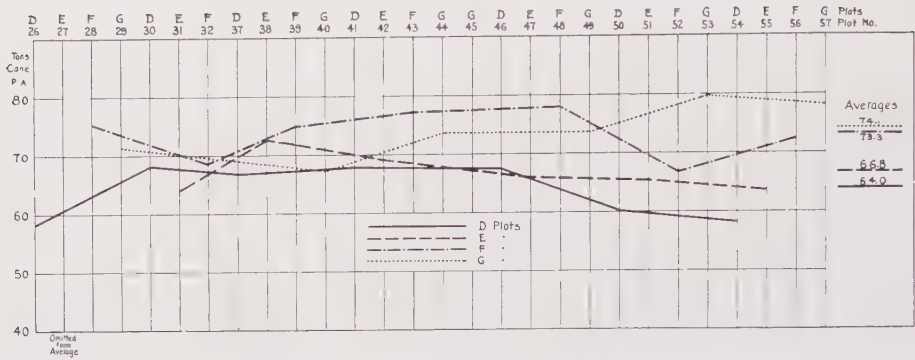


Fig. 2.

These results of the plant crop would indicate that 230 pounds of nitrogen per acre was the most profitable amount of this element to use under the conditions of this test.

The results of the first ratoon crop are summarized as follows:

## AMOUNT OF NITROGEN—SUMMARY OF RESULTS

## First Ratoon Crop—1927

Plots	No. of Plots	Treatment	T. C. P. A.	Yields Q. R.	T. S. P. A.
D	7	140 pounds Nitrogen.....	57.5	7.23	7.94
E	7	190 pounds Nitrogen.....	67.6	7.52	8.99
F	7	240 pounds Nitrogen.....	74.2	7.96	9.29
G	7	290 pounds Nitrogen.....	78.2	8.13	9.62

The results of the first ratoon crop show substantial gains up to 290 pounds. The last 50 pounds of nitrogen produced an increased yield of one-third of a ton of sugar per acre.

## DETAILS OF EXPERIMENT

**Object:** To determine the most profitable amount of nitrogen to use.

**Crop:** H 109. Planted July, 1923.

**Location:** Pioneer Mill Company, Field G2. Elevation 450 feet.

**Layout:** 28 plots, of variable size, 7 repetitions of each treatment. Experimental area, 2,221 acres net.

# NITROGEN-AMOUNT TO APPLY Pioneer Mill Co. Exp. 23, 1927 crop First Ratoons

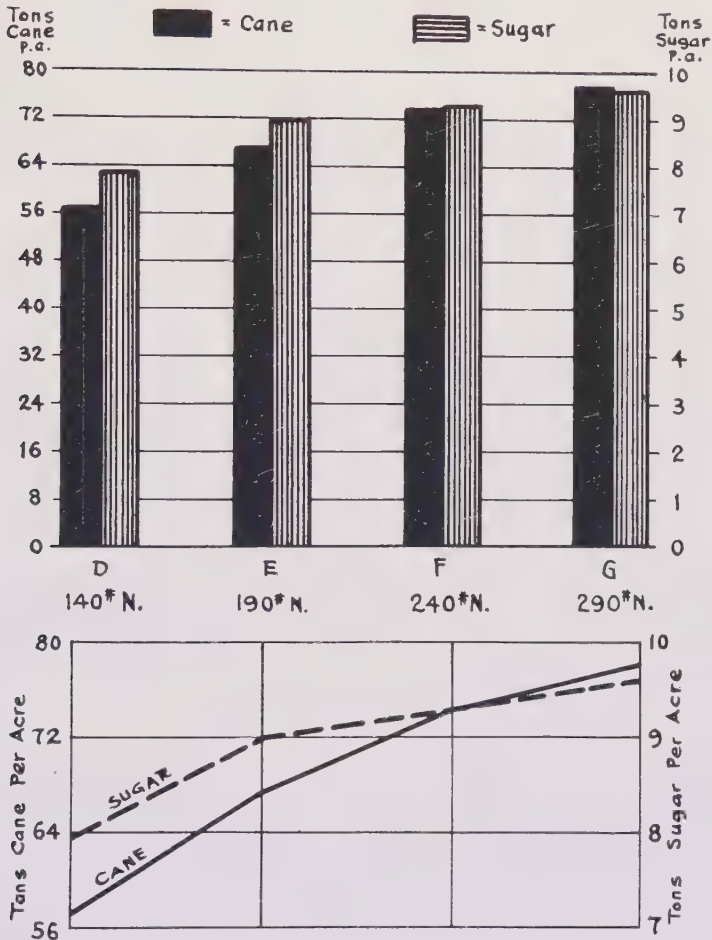


Fig. 3.

## FERTILIZATION OF PLANT CROP

Sept., 1923

Plots	No. of Plots	Sept., 1923			Jan., 1924		Feb., 1924		Totals	
		Amm. Sul.	Acid Phos.	Pot. Sul.	N. S.	N. S.	N. S.	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
D	7	220	476	100	563	...		132	100	50
E	7	342	476	100	563	147		180	100	50
F	7	463	476	100	563	308		230	100	50
G	7	585	476	100	563	470		280	100	50

Acid Phosphate = 21% P<sub>2</sub>O<sub>5</sub>.

Ammonium Sulphate = 20.5% N.

Nitrate of Soda = 15.5% N.

Sulphate of Potash = 50% K<sub>2</sub>O.

## NITROGEN - AMOUNT TO APPLY

Pioneer Mill Co. Exp. 23, 1927 Crop

First Ratoons

Curves Showing Cane Yields Per Acre By Plots.

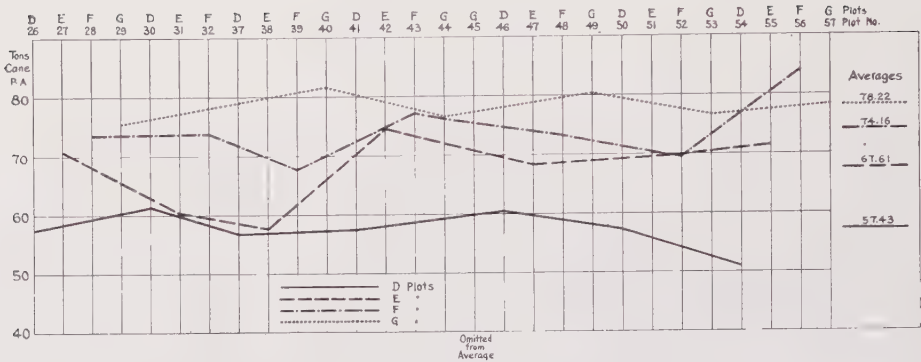


Fig. 4.

## FERTILIZATION OF FIRST RATOON CROP—LBS. PER ACRE

July, 1925								
Plots	No. of Plots	Amm. Sul.	Acid Phos.	Pot. Sul.	Feb., 1926 N. S.	N	Totals P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
D	7	342	750	204	452	140	150	100
E	7	463	750	204	613	190	150	100
F	7	585	750	204	774	240	150	100
G	7	707	750	204	936	290	150	100

Ammonium Sulphate = 20.5% N.

Acid Phosphate = 20% P<sub>2</sub>O<sub>5</sub>.Potash Sulphate = 49% K<sub>2</sub>O.

Nitrate of Soda = 15.5% N.

**Progress:** September 26, 1923—Experiment laid out and first fertilizer applied.  
 January 18-19, 1924—Nitrate of soda applied by plantation.  
 February 14, 1924—Nitrate of soda applied to "E," "F" and "G" plots.  
 May 2-5, 1925—Plant crop harvested.  
 July, 1925—First season fertilizer applied to ratoons.  
 February 9, 1926—Second season nitrate of soda applied to experiment.  
 January 6-8, 1927—First ratoon crop harvested.

R. E. D.

## Relationship Between Phosphoric Acid, Lime Used and Amount of Press Cake

BY J. H. PRATT

The tabulation below gives weekly figures from laboratory records showing relationship between the  $P_2O_5$  of crusher juice, amount of lime used and the percentage of press cake at the Pioneer Mill Company's factory for the crop of 1926.

There are several influencing factors which should be born in mind.

1. Several weeks, we boiled off the juice in the settling tanks, so there would be about 4 tons more mud these weeks than usual. I have no record of which weeks we did this, but think that the mud per cent cane should be corrected as follows: December 5 add .10 per cent, December 12 deduct .05 per cent, December 19 deduct .04 per cent, January 9 add .04 per cent. I think the rest of the weeks are all right.

2. We ground a considerable quantity of sour cane during the latter part of December, which gave these weeks an undue amount of mud.

3. Our lime figures are those of the lime slaked and not those actually used. I do not think that this would make any serious difference except to the first week and last week of the crop.

4. The actual  $P_2O_5$  in the mixed and crusher juice is an arithmetical average based on the number of samples and not on the tons of cane. This difference is probably not very serious either.

5. In getting the calculated  $P_2O_5$  in crusher juice, I multiplied the tons of cane from each field by the average  $P_2O_5$  for that field. This is not strictly accurate as most of our fields are on a steep slope and the  $P_2O_5$  is higher at the bottom of the field than it is at the top. Some of the weeks, when we were getting perhaps 40 per cent of our cane from one field, may be slightly off for this reason.

6. The pH of the mixed juice is the cold and not the hot juice.

7. The pH of the clarified juice does not include press juice or the juice from tanks held over shutdowns of more than 3 hours.

8. During part of the crop some of the lime reported was used in the mud while at other times we cut this out. This might make some difference in the figures.

9. As about half the crop was ground single shift, I have included the approximate hours ground per day, although I don't think that the extra lime added to the juice held over night would make much difference to the averages.

TABLE SHOWING MUD PER CENT CANE, POUNDS LIME PER TON CANE, pH OF JUICES, ACTUAL  $P_2O_5$  IN MIXED AND CRUSHER JUICE AND CALCULATED  $P_2O_5$  IN CRUSHER JUICE

Week	Per cent	Lbs.	Actual $P_2O_5$		Cale.	pH of Juice			Hours per day
	mud	lime	mixed	crush	crush	mixed	clarified	syrup	
12-5	4.22	2.45	...	...	.038	8.94	7.96	7.31	14
12-12	4.77	1.46	...	...	.039	8.71	7.66	7.22	21
12-19	4.93	1.62	...	...	.022	8.75	7.62	7.37	22½
12-26	5.17	2.34	...	...	.020½	9.01	7.66	7.44	17½
1 -2	4.33	2.13	...	...	.022¼	9.07	7.70	7.43	21
1 -9	3.58	1.46	...	...	.022	8.99	7.82	7.49	20
1 -16	4.13	1.47	...	...	.020½	8.86	7.71	7.44	22½
1 -23	4.17	1.37	.024	.025½	.023	8.86	7.65	7.31	19½
1 -30	3.52	1.35	.021	.022¼	.020¾	8.81	7.67	7.48	23
2 -6	3.30	1.35	.019	.019	.019½	8.89	7.67	7.49	19
2 -13	3.87	1.36	.018	.018	.018	8.80	7.68	7.56	21
2 -20	4.02	1.45	.017	.018¾	.018¼	8.73	7.69	7.52	21
2 -27	3.18	1.40	.016½	.017	.017½	8.75	7.71	7.61	21
3 -6	3.56	1.36	.018½	.019	.018¼	8.80	7.67	7.51	19
3 -13	4.23	1.52	.016	.017	.017½	8.65	7.64	7.44	17
3 -20	4.09	1.57	.015	.016	.015½	8.70	7.68	7.40	16
3 -27	3.49	1.50	.016	.017	.016¼	8.80	7.74	7.40	12
4 -3	3.41	1.64	.014	.015	.014	8.73	7.75	7.41	11
4 -10	3.09	1.41	.014	.015¾	.016	8.62	7.68	7.31	12
4 -17	3.11	1.53	.014	.015¼	.016	8.88	7.86	7.41	10
4 -24	3.61	1.49	.014½	.014¾	.015	8.83	7.86	7.46	10½
5 -1	3.64	1.48	.016	.017½	.017½	8.75	7.90	7.43	10½
5 -8	3.16	1.47	.019	.020	.016½	8.83	7.81	7.45	10½
5 -15	3.08	1.43	.018	.018	.017	8.58	7.73	7.43	11
5 -22	3.29	1.62	.022	.022½	.018	8.62	7.74	7.42	11½
5 -29	3.02	1.43	.018	.017½	.020½	8.77	7.86	7.37	11½
6 -5	3.20	1.70	.026	.026½	.021	8.72	7.72	7.30	11
6 -12	3.15	1.63	.021	.021½	.019	8.80	7.77	7.40	11
6 -19	4.73	2.00	.029	.030½	.022½	8.69	7.69	7.51	8
6 -26	3.63	2.05	.026½	.027	.025	8.73	7.67	7.54	10½
7 -2	4.65	2.30	.043	.049½	.050½	8.62	7.52	7.29	9½
7 -10	4.85	1.82	.053½	.064	.064½	8.79	7.35	7.05	8

## Irrigation Investigations at Waimanalo

BY T. K. BEVERIDGE  
*Agriculturist, Waimanalo Sugar Company*

Two reports on the cooperative irrigation investigations at Waimanalo have appeared in the *Record* of April, 1924, and October, 1925. The present report deals with the continuation of these studies along several new lines which have been developed since the last report. The work has been continued as a joint endeavor of the Experiment Station, H. S. P. A., and Waimanalo Sugar Company.

## SOURCES, AMOUNTS OF IRRIGATION WATER, AND DITCHES

Waimanalo Sugar Company is entirely dependent on the rainfall for its source of irrigation water and has no artesian supply whatsoever. Under the best of conditions the maximum economical supply available for any one day is a little over ten million gallons; the average daily delivery for the year, however, is only slightly over eight million gallons. This supply is delivered to the plantation from three sources, as follows:

1. The Maunawili-Waimanalo Ditch;
2. The Kailua Pump Ditch;
3. The Lagoon Pump Ditch.

The Maunawili-Waimanalo ditch, receiving its water from numerous small springs and streams along its course, runs along the top of the plantation, and its delivery averages about two million gallons daily.

The Kailua pump ditch is fed from a large swamp at Kailua. This swamp is nothing more than a storage reservoir for the surface run-off from the Kailua Valley. The water, lifted 180 feet by pumps to a series of tunnels, enters the premises about a hundred feet below the Maunawili-Waimanalo ditch and runs through the middle portion of the plantation. This source supplies close to four million gallons of water a day or approximately one-half of the irrigation water.

The lagoon pump ditch runs through the lower levels of the plantation about one hundred feet below the Kailua ditch. The water is lifted 80 feet from a lagoon on the plantation at the rate of a little over two million gallons per day.

All of the ditches on the plantation, with the exception of some tunnels and a few short stretches of concrete ditch, are of the open-cut type running through the subsoil. These ditches average three feet in depth and three and one-half feet in width with a fall of about two-tenths per hundred feet.

## WATER SUPPLY—SEASON 1926

	Maunawili-Waimanalo	Lagoon pump	Kailua pump
January . . . . .	3,719,790	478,640	.....
February . . . . .	12,524,680	29,688,430	43,999,200
March . . . . .	62,955,460	61,639,770	141,980,450
April . . . . .	66,087,190	71,863,570	117,006,210
May . . . . .	61,521,710	77,659,280	179,487,570
June . . . . .	63,348,260	31,020,960	45,906,740
July . . . . .	69,132,070	66,289,760	168,464,470
August . . . . .	61,099,940	78,343,910	191,057,040
September . . . . .	57,455,160	52,823,630	79,928,070
October . . . . .	68,253,570	39,301,020	50,257,090
November . . . . .	55,680,840	15,832,340	7,528,190

## DITCH SEEPAGES

The ditch seepage losses at Waimanalo, although very high in some particular spots, are not abnormally large for this type of plantation ditch. From data that have been obtained during the year, it has been found that the total loss of

## Waimanalo Sugar Co.

Graph showing the amounts of irrigation water used per month over a period of three years, compared with the average monthly rainfall for the same period and showing how the rainfall varied from normal. Normal being a period of 36 years.

Million  
Gallons  
350

- Inches Rainfall Per Month 36 Year Average.
- - - Million Gallons Irrigation Water 3 Year Average 1924-1926.
- · - - Inches Rainfall Per Month 3 Year Average 1924-1926

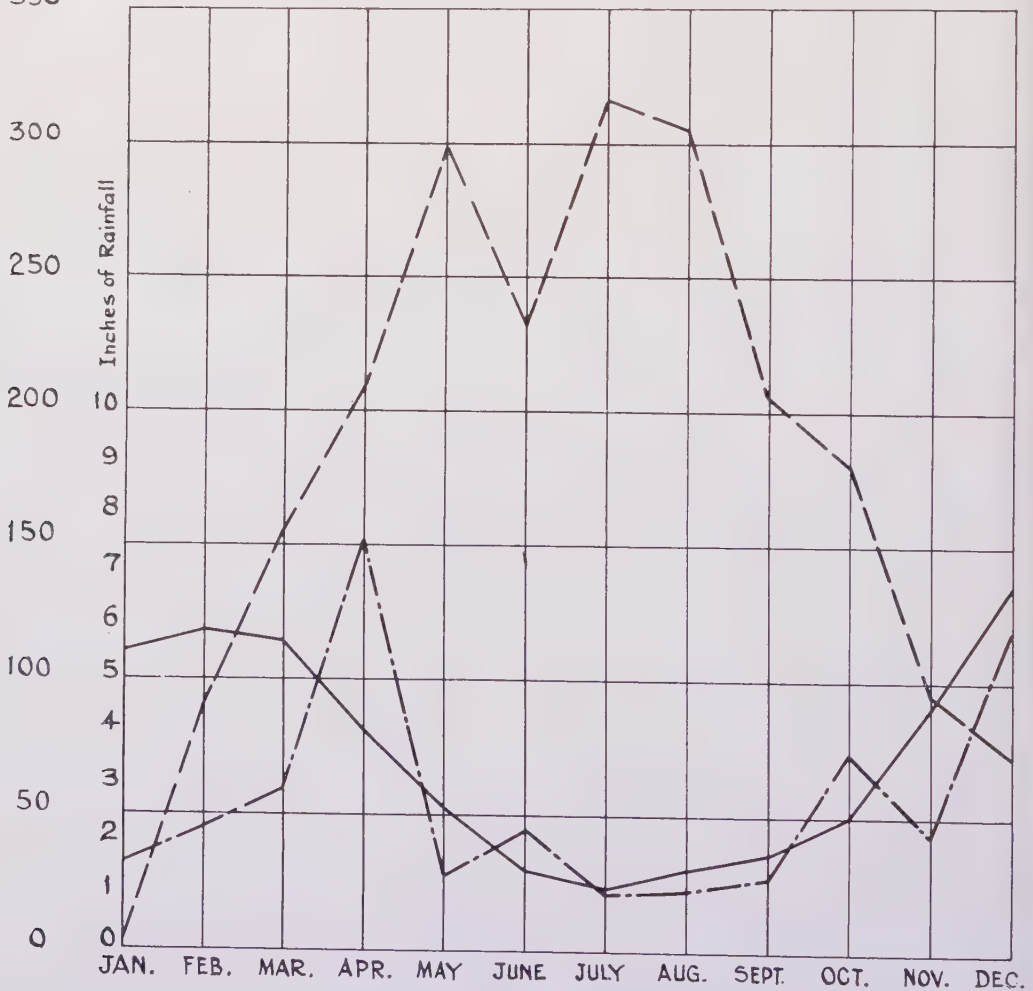


Fig. 1.

water over the whole plantation is only 20.60 per cent of the entire supply. This amounts approximately to 9.00 per cent per mile, showing that the ditches have been kept in a very good state of repair.

Seepage tests have been made on all of the ditches on the plantation so that whenever improvements are made on the ditches, the worst spots are gone over first and the amount of water that is being lost by ditch seepage is gradually being lessened.

Figures are presented below to show how it was possible to cut down losses in one ditch through seepage tests:

#### SEEPAGE LOSSES—MAUNAWILI DITCH

##### First Test

Location of measuring station	Distance between stations	Total flow gallons per 24 hours	Seepage loss gallons per 24 hours	Per cent of total flow lost	Per cent loss per mile
Field 16.....	.....	2,649,000	.....	.....	.....
Field 15.....	1,315 feet	2,340,000	139,000	5.23	21.00
Field 14.....	7,275 feet	2,113,000	356,000	14.42	6.67
Field 3.....	10,165 feet	1,299,000	1,170,000	47.39	17.13
Field 1.....	5,623 feet	1,125,000	1,344,000	54.43	6.38

#### WAIMANALO SUGAR CO. CROPPING & IRRIGATING

Tentative harvesting and irrigating schedule for five successive crops showing the irrigation gradually tapers off after the month of June. June and July are the months when the greatest amount of irrigation water is used under normal conditions.

There is a gradual falling off of the economical water supply after these two months, September being the month when there is the least available water.

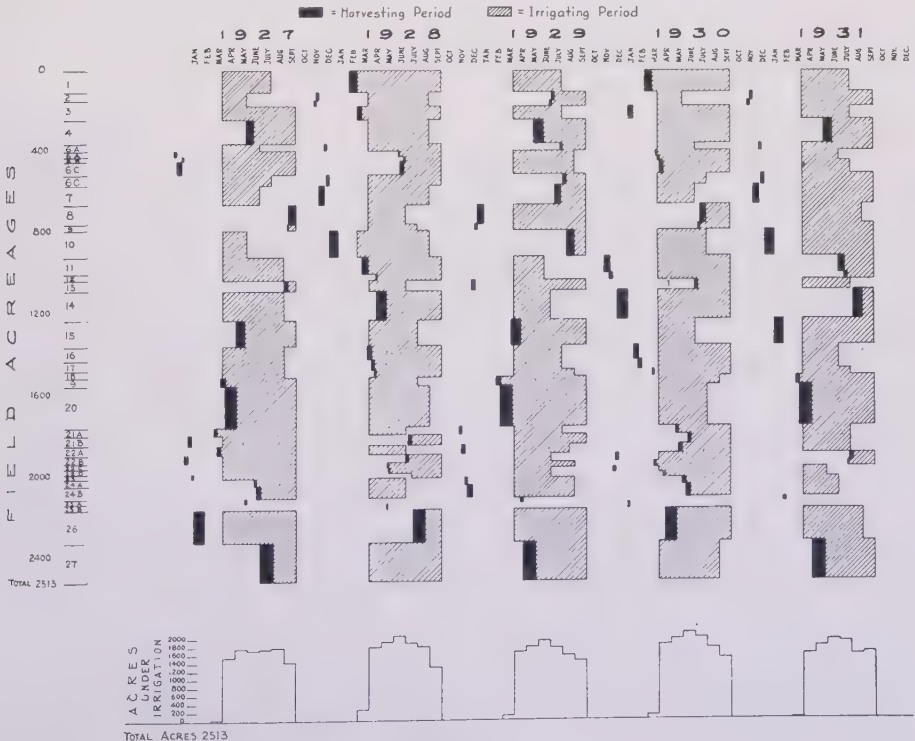


Fig. 2.

### Later Test After Repairing Ditches

Field 16.....	.....	2,604,000	.....	.....	.....
Field 15.....	1,315 feet	2,469,000	135,000	5.17	20.80
Field 14.....	7,275 feet	2,146,000	458,000	17.58	9.01
Field 10.....	3,075 feet	1,984,000	620,000	23.79	10.69
Field 4.....	4,200 feet	1,981,000	723,000	27.76	4.84
Field 3.....	2,890 feet	1,745,000	859,000	32.95	9.56

During the year the question was brought up as to the loss of water in straight ditches that had cane growing along them. Two typical ditches were selected and weirs were installed at the tops and bottoms of these ditches. Water was run into the ditches twice, once when the cane was large, and once after the cane had been cut. On both occasions the weirs were identical, the same amount of water was run over the top weirs and the water was run over the bottom weirs the same length of time before readings were taken:

### STRAIGHT DITCH SEEPAGES WITH CANE

Location of weirs	Distance between weirs	Total flow gallons per 24 hours	Seepage loss gallons per 24 hours	Per cent of total flow lost	Per cent loss per mile
Field 13 Top.....	.....	604,000	.....	.....	.....
Field 13 Bottom...	500 feet	490,000	114,000	18.87	200.10
Field 10 Top.....	.....	497,000	.....	.....	.....
Field 10 Bottom...	1,700 feet	292,000	205,000	41.25	128.10

### STRAIGHT DITCH SEEPAGES WITHOUT CANE

Field 13 Bottom...	500 feet	585,000	19,000	3.15	33.40
Field 10 Bottom...	1,700 feet	460,000	37,000	7.45	23.10

### MEASURING STATIONS AND MEASURING DEVICES

The measuring stations used are of two classes, the first being the main stations and the second the field stations. All of the main stations are of the standard rectangular contracted weir type, installed at the head of each ditch so that an accurate measurement is obtained of all of the water as it enters the plantation ditches. Water stage recorders, either of the Gurley or Freiz types have been installed with the weirs and are in constant use.

Field measuring stations are located at the end of each field in all main ditches. This method of installation is made possible by the fact that all of our ditches run at right angles to our fields. This eliminates the problem of putting in stations on each lateral or wing ditch and cuts down the number of stations to the minimum. All of the field measuring stations are of the submerged orifice type and when used correctly prove very satisfactory. They are, in addition, simple to operate. The Great Western Orifice Meter is used in conjunction with the submerged orifices to record the amount of water passing through any particular field measuring station. Five different sized orifices are used, depending on the

## Waimanalo Sugar Co.

Graphs showing the amounts of irrigation water  
and rainfall and the average monthly growth Curve.

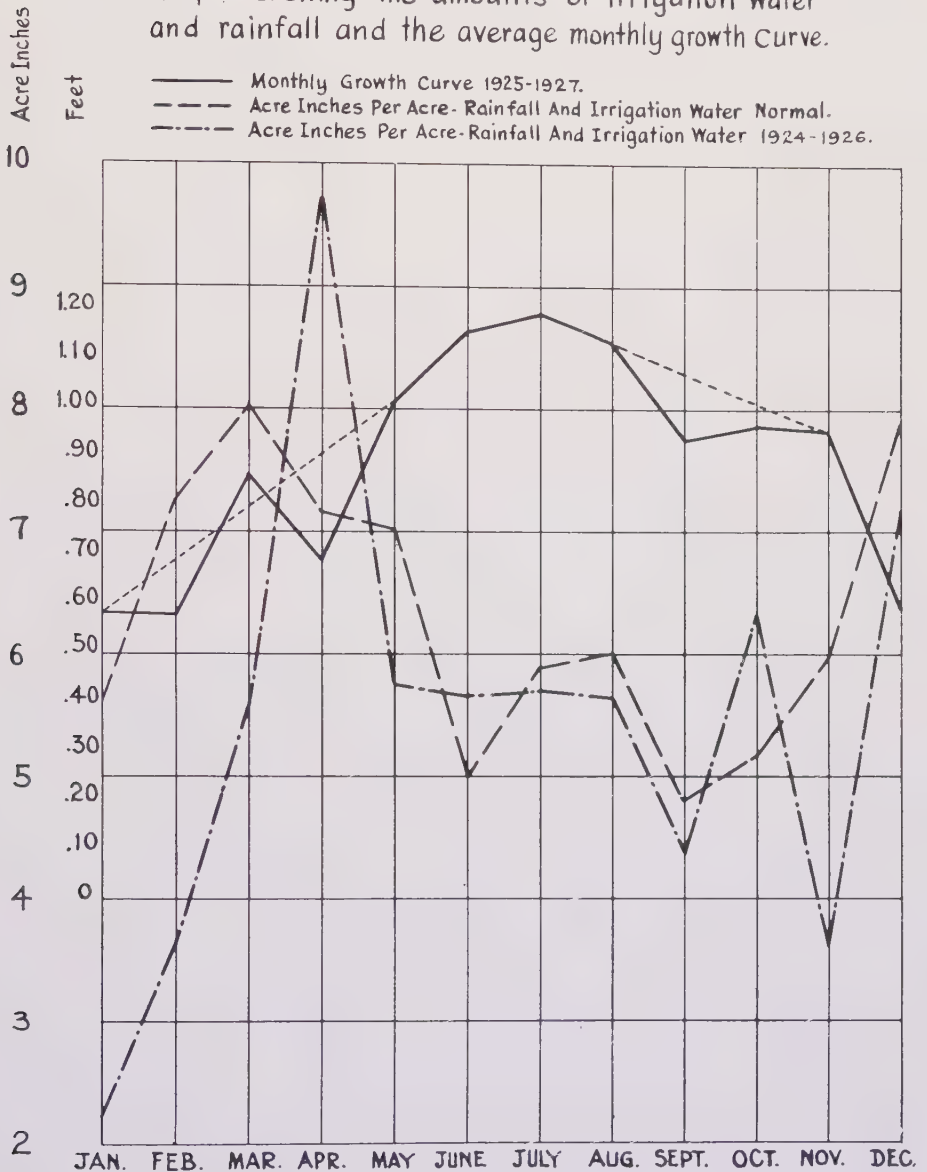


Fig. 3.

amount of water that passes through the measuring station and all can be interchanged easily and quickly.

One man has charge of setting the orifices and reading the meters and it is his duty to attend to all matters pertaining to the proper working of the various stations. In the morning he receives a list of the fields which are receiving water for the day. He immediately sets out to make the necessary adjustments for

the proper measuring of the water. If the irrigation is to be continued for several days the orifices remain in position all the time, except in cases where it is necessary to make changes. He always starts at the upper portion of the ditch and works down the field with the water.

The meters in use are read once a day at approximately the same hour, so that it is a very simple matter to obtain the amount of water passing through any given station. There are times, however, when, due to unforeseen circumstances, several changes have to be made during the day, but as a rule only one adjustment a day is necessary. The meter readings are turned in the following morning. The amount of water taken for any given field is the difference between the amount of water passing two stations, one at the end of the field, which is above this particular field and the other at the end of the field using the water. This system is used on all of the fields and so far has proven very satisfactory.

#### THE OBJECT OF WATER MEASUREMENTS

The objects of carrying on this careful measurement of water to all the fields are quite numerous, but chief among them is the duty of water, and this is the principal one here. How much sugar can be produced from a million gallons of irrigation water? This alone is a question which is being brought up more and more and the work here is being done with the idea of answering this question for the conditions to be met at Waimanalo.

Some questions the water measurements brought out very clearly are (1) Just how efficiently are the men using the water given them? (2) What are the irrigators doing in the fields? (3) Are they applying the water properly and yet covering the ground? After the first two irrigations this year it was possible to make the men in the fields cover about twice the ground that they were doing before this work was started. This increase in irrigating efficiency has brought the work up to a high degree of proficiency.

#### USEFUL INFORMATION RESULTING FROM THE MEASUREMENT OF IRRIGATION WATER

The information that can be obtained from this work is very important for the field man. It is possible through these measurements to tell with a considerable degree of accuracy (a) How much water is being applied per acre per round. (b) The amount of water each man is handling per round. (c) How much area is being covered and just how much water is required for each field. A very careful check can be kept of each individual field and after several irrigations a pretty fair average can be arrived at as to what a man can be expected to accomplish in each field. It is then just a question of careful supervision to keep the men up to whatever mark has been reached.

Measuring the water also helps to distribute irrigating cost to the fields on a more definite basis. The exact amount of water going to each field can be accounted for and the field charged accordingly. This method eliminates the

old way of distributing the amount of water in accordance with the irrigating man days.

One important result of this work of water measurements to fields is the knowledge of how much of the water that is delivered to the plantation is actually put on the fields. From the data obtained, month by month, the actual ditch seepage loss is determined. For plantations that have a very high water cost this phase of water measurements will be a very important and interesting one, especially in cases where the ditches are not lined. Data thus collected will give a very good idea as to whether the cost of lining these earth ditches will be warranted.

Month	Per cent loss of total flow	Approx. distance water traveled	Per cent loss per mile
February .....	19.75	2.20 miles	8.97
March .....	10.47	1.32 miles	7.93
April .....	32.46	3.00 miles	10.82
May .....	34.91	3.00 miles	11.64
*June .....	45.79	3.55 miles	12.90
July .....	27.94	2.50 miles	11.18
August .....	21.63	2.50 miles	8.65

The general plan of irrigation that is carried out here is quite similar to that used by other plantations, except that the beginning and end of the irrigation season is largely decided by means of soil moisture determinations. Irrigation commences in the spring as soon as the soil moisture has dropped appreciably below the optimum point in many of the fields. In the same way the season is closed in the fall, when the soil moisture has increased and the appearance of the cane indicates an adequate supply of water in the soil. During the irrigation season, as far as possible, the irrigation in each field is carried out by a regular series of rounds. The interval between rounds varies for each field and with each irrigation. No regular irrigation schedule has been worked out, as yet, and it does not seem practical to do so as conditions vary continually. In consequence of this variation, the water has to be put on where it is most needed and where the best results will be obtained. A very careful study of the individual fields has been necessary.

Growth measurements have been carried on in all the fields of the plantation, in conjunction with the measurement of the irrigation water applied. A typical series of these results is shown in Figs. 4, 5 and 6.

The conclusion has been reached from this work that the youngest fields should have the first consideration as far as irrigation is concerned, and so far excellent results have been obtained by following out this plan. By doing this a better stand of cane is obtained, the cane closes in more quickly, to shade the soil, which in turn helps to save considerable water, and there is every indication that the yield will be appreciably better.

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\* This figure was high due to the fact that the amount of water flowing through this ditch was comparatively small compared with other months and the water was used at a greater distance.

# WAIMANALO SUGAR COMPANY

Poor Field

Field 4.

Graphs showing the relation of water and temperature and its effect on the growth of cane. Three typical fields are shown, one poor, one medium, and one good.

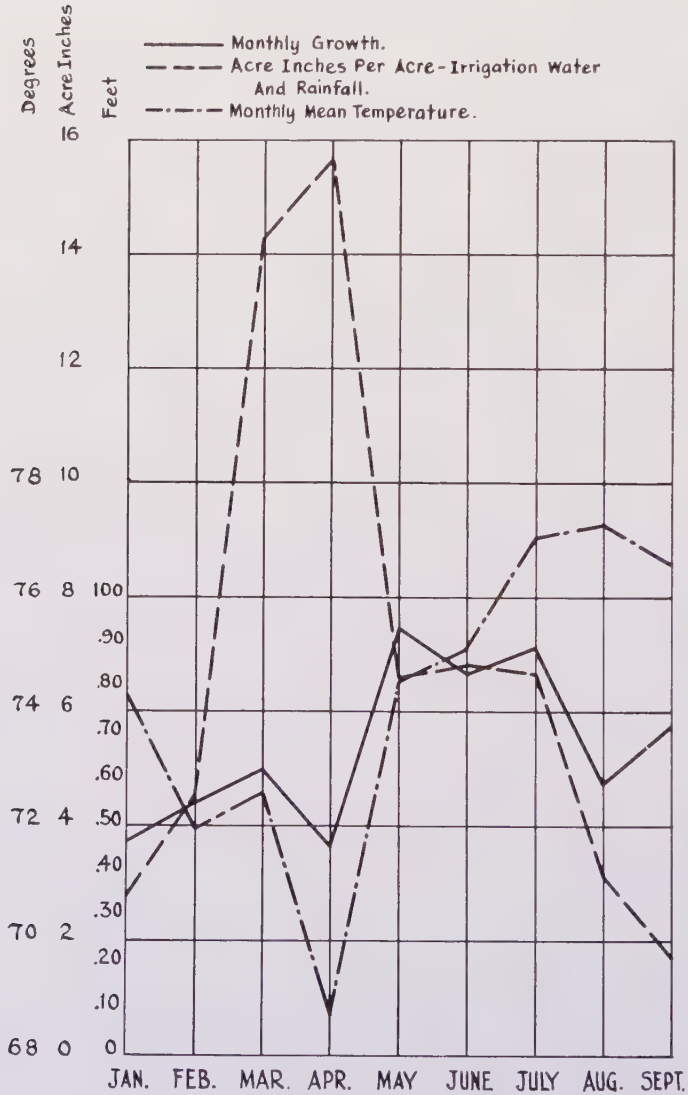


Fig. 4.

# WAIMANALO SUGAR COMPANY

Medium Good Field.

Field 27.

Graphs showing the relation of water and temperature and its effect on the growth of cane. Three typical fields are shown, one poor, one medium, and one good.

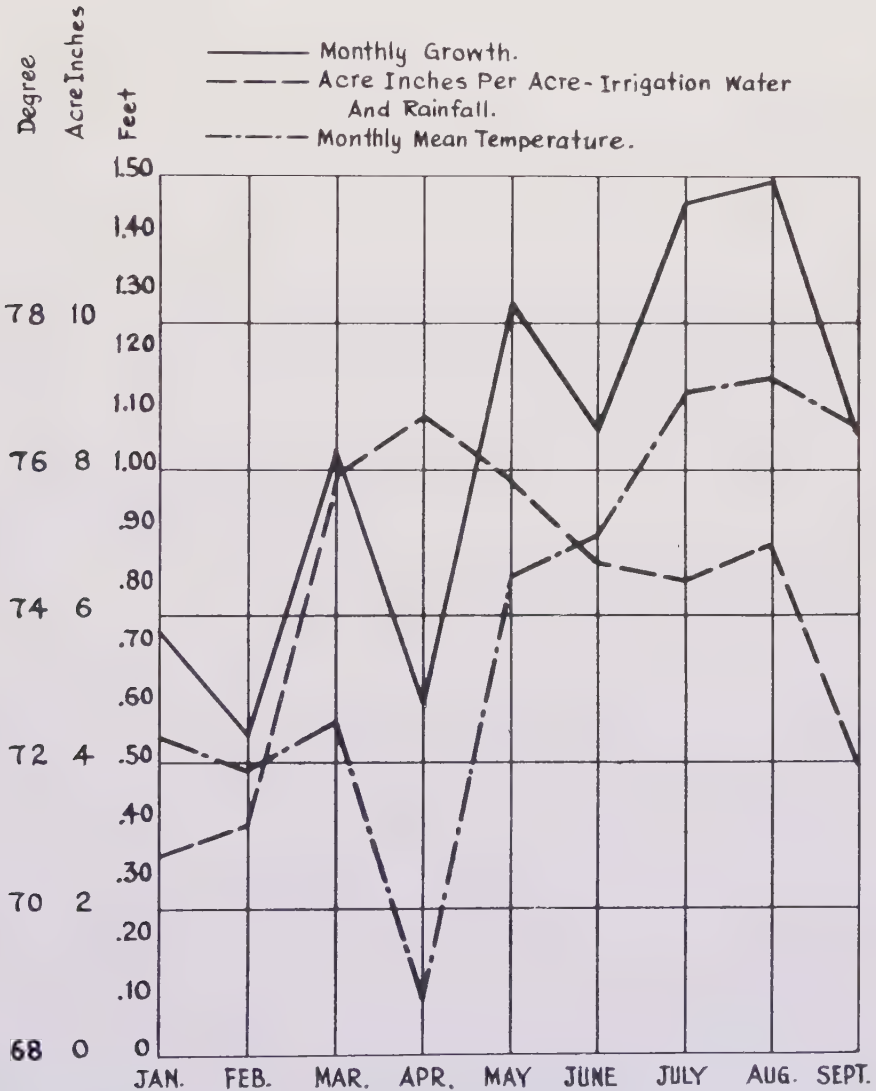


Fig. 5.

# WAIMANALO SUGAR COMPANY

Good Field. Field 26.

Graphs showing the relation of water and temperature and its effect on the growth of cane. Three typical fields are shown, one poor, one medium, and one good.

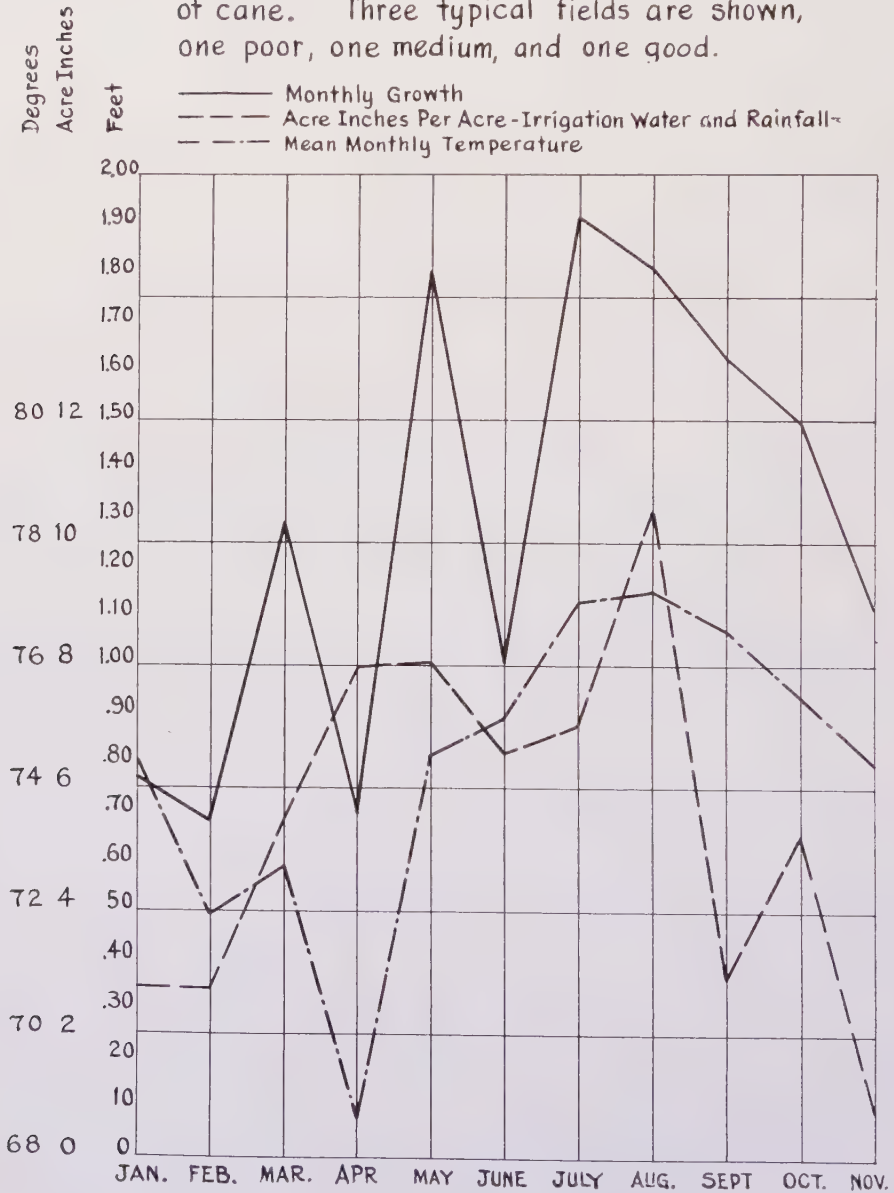


Fig. 6.

The following is a form of the data that are kept for each individual field and crop:

Field No.	Round No.	Total acres	Total for round Gallons	Man days	Age of cane	Gallons per Man day	Acre per man day	Acre in. per man day
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When a round has been completed for any field the necessary data are immediately computed and compared with the previous report to see if there has been any improvement, particular attention being paid to the columns, Acres per Man Day, and Acre Inches per Man Day.

It has been found in carrying on this work that the amount of water that a man can handle economically per day varies considerably with the conditions under which he is working. A man, in order to do his work efficiently, needs a considerably larger stream of water in old cane than in a field that is about a foot high. Likewise he takes much less water in a young plant field than in a young ratoon field.

#### FIELD 13—1927 SHORT RATOONS

R.	Age months	Interval	Gallons per man per day	Gallons per acre	Acre per man day	Acre inches per man	Acre inches per acre
1	2	8	87,280	85,470	1.021	3.214	3.148
2	3	18	131,410	168,284	0.781	4.84	6.20
3	5	11	141,768	138,831	1.021	5.22	4.97
4	7	13	130,340	159,550	0.817	4.80	5.88
5	8	12	120,543	93,345	1.249	4.43	3.44
6	9	5	223,241	125,786	1.770	8.22	4.63

#### FIELD 23—1927 RATOONS

1	8	11	80,500	96,840	0.831	2.96	3.566
2	9	7	155,910	199,283	0.782	5.74	7.34
3	10	8	161,335	151,631	1.064	5.94	5.58
4	11	12	139,228	172,727	0.806	5.13	6.36
5	11	3	153,305	121,030	1.267	5.65	4.46
6	12	9	153,557	133,397	1.108	5.66	5.10

#### FIELD 24A—1927 RATOONS

1	8	23	127,129	262,895	0.484	4.682	8.682
2	9	17	171,818	203,034	0.846	6.328	7.477
3	11	22	112,333	146,016	0.769	4.14	5.38
4	13	20	196,677	180,170	1.059	7.24	6.63
5	13	18	257,136	197,505	1.302	9.47	7.27
6	14	26	250,126	295,570	0.846	9.21	10.88

The above tables show round reports for three typical fields and crops. Fields 13 and 23 are ideal fields of a black loamy type of soil with a high water-holding capacity. Field 24A has a coral subsoil and is a very open soil. This brings out the relation between the amounts of water applied per acre per round, the age of cane, and the interval, very clearly. The amount of water required per acre round is much less in small cane than in large cane.

# THE ARRANGEMENT OF A CROPPING CYCLE IN RELATION TO WATER ECONOMY

The problem of harvesting crops at the best time and with a view to economically applying the limited water supply to the growing crops to the best advantage, or, in other words, to get the maximum duty of the available water, has been a most difficult one to solve. A plan whereby every weather condition can be taken advantage of in helping the younger crops along has been drawn up and seems to be a very good one. This cropping cycle, as it might be called, is divided into three periods and is as follows:

The harvesting of those fields which are to be short cropped is begun about the first of November and continued through into February. This harvesting will cover an area of some four hundred acres. Here a shutdown period is introduced in order to prepare these fields and clean up any other fields that need attention. When harvesting is again started, those fields which are to be plowed and planted or long cropped, are taken off. This second period will be slightly longer than the first and about six hundred acres will comprise the area to be harvested. After this a short time is taken up in conditioning the fields. In the last grinding period approximately four hundred acres of short crops are harvested yearly.

By studying this schedule it will be seen that during the month of our water shortage, which is September, the smallest area occurs under irrigation. By starting harvesting the latter part of the year the early rains are utilized to start the new crops.

The saving in water by short cropping is pretty well brought out by the data obtained during the crop of 1926. Of course a certain amount of data had to be assumed. Actual figures will be obtainable at the end of the 1927 crop.

## Crop 1926

	Long ratoons	Short ratoons
Tons cane per acre.....	58.27	51.03
Quality ratio .....	9.19	8.70
Tons sugar per acre.....	6.34	5.86
Average age, months.....	21.0	16.0
Tons sugar per acre per month.....	0.302	0.366
Gallons water applied per acre.....	1,672,300	1,371,700
Gallons water per ton sugar.....	263,700	227,480
Tons sugar per million gallons.....	3.79	4.27

These data do not include the rainfall.

## SUGAR PRODUCED PER MILLION GALLONS OF WATER

Since approximately the same amount of irrigation water is used each year it will be safe in assuming that the total amount of irrigation water used during the year 1925 would be the amount of water used to produce 7,814.69 tons of sugar. Sugar produced per million gallons of irrigation water for this crop was 3.76 tons.

From irrigation experiments conducted during 1924 and 1925 it has been found that on the "plantation practice" plots one million gallons of irrigation water produced 5.16 tons of sugar on one plot and 11.51 tons of sugar on another. These two plots, however, represented two types of soil of very different characters, the former being a reddish type and very porous with a relatively low water-holding capacity, and the latter a heavy black loam type with a relatively high water-holding capacity.

## EXPERIMENTS

The irrigation experiment that was carried on in Field 15 was continued into the ratoon crop and will be harvested again in 1927. The acreage was increased to include 7 plots of approximately one acre each. Two plots are receiving irrigation every two weeks; two plots receive irrigation once a month and the three check plots receive the regular plantation irrigation. All of the plots received uniform fertilization, so that any gain can be attributed to the irrigation methods. The growth curves show a considerable increase in favor of the extra irrigated plots and there is every indication that there will be an increase in yield on these plots.

An irrigation test on the method of irrigation used here was conducted over a short interval and may be of some interest. Two irrigations were made using the regular Hawaiian system. One irrigation was made to change from the Hawaiian method to the method used here, and then two irrigations were conducted the same way irrigation is conducted here. Time cards and the amount of water used under the two systems were kept. The same men were used to irrigate the same areas under both tests.

## COMPARISON OF METHODS OF IRRIGATING

(1) Hawaiian furrow system, every row irrigated, one irrigation up the watercourse and one irrigation down, compared with (2) system used at Waimanalo, two irrigations down and up.

(1)						
Irrigation	No. of men	Acres covered	Time per irrigation	Total gal- lons used	Acre inches per acre applied	Acres per man day
First up .....	3	0.933	3.58 hrs.	68,640	2.55	0.869
Second down .....	2	0.933	5.08 hrs.	71,330	2.65	0.918
(2)						
First down and up...	1	0.933	4.58 hrs.	58,760	2.18	2.037
Second down and up..	2	0.933	2.75 hrs.	44,090	1.64	1.697

The system used at Waimanalo, contrasted to the usual Hawaiian practice, is represented in Fig. 7. In the Waimanalo modification, the irrigator going down the furrow is irrigating the odd-numbered furrows 1, 3, 5, etc. Coming back up the watercourse, he will irrigate the even-numbered furrows 20, 18, 16, etc. This plan is believed to possess several advantages, besides covering a greater area

# HAWAIIAN FURROW SYSTEM

EVERY ROW IRRIGATED

WAIMANALO MODIFICATION

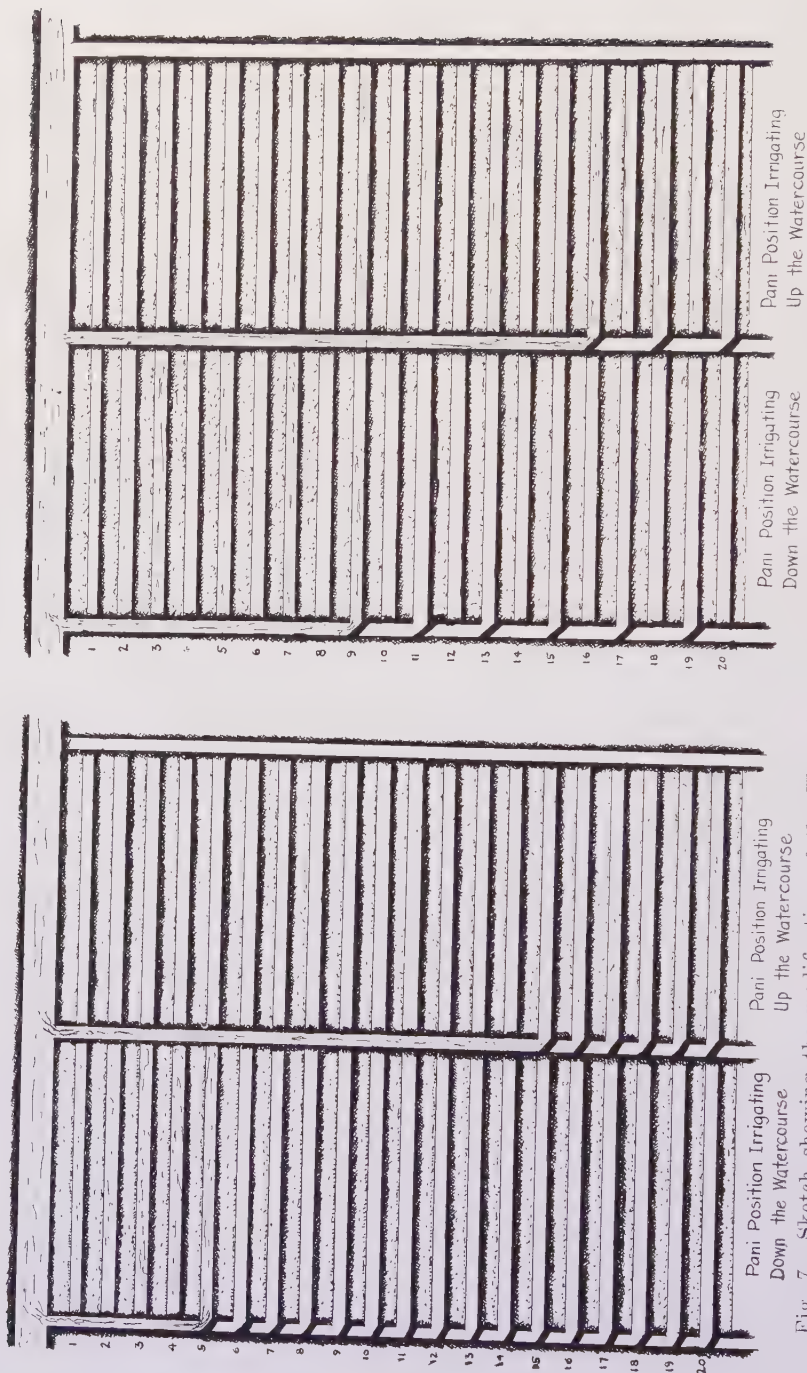


Fig. 7. Sketch showing the modification of the Hawaiian furrow system of irrigating that is being used with such good results at Waimanalo.

as indicated in the preceding test. It has been found quite advantageous to leave the panis in place in the watercourse at alternate lines. Such an arrangement prevents washing of watercourses during heavy rains or when water is accidentally turned into the level ditches or watercourses.

### THE COST OF WATER MEASUREMENTS

Most plantations, before starting work of this type, will be interested, primarily, in the cost of water measurements. The initial cost of this work, if undertaken on a large scale, will be enough to make any one hesitate before starting

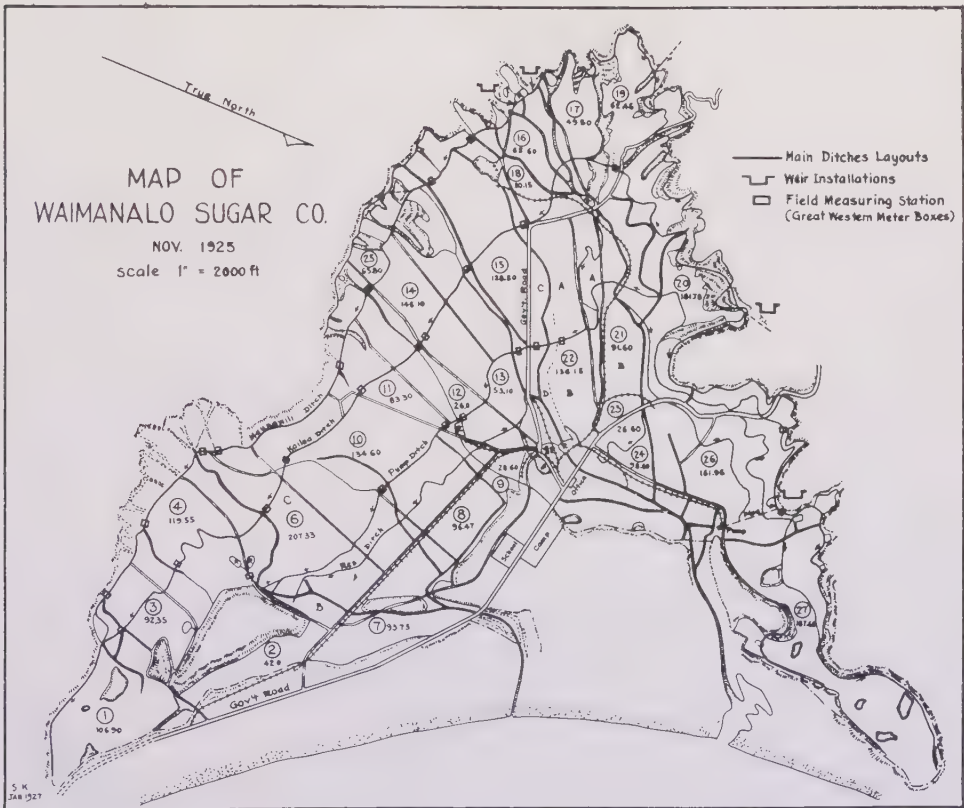


Fig. 8.

such an endeavor. But it is not the initial cost of a thing that counts. The big question of work of this kind is, will it pay? There seems to be no question that the work here has more than paid for itself already. The increase in irrigating efficiency that has been produced is more than sufficient to justify the cost of the investigation.

Here are some cost figures to give anyone starting work of this nature an idea of the expenditure necessary and the returns that might be expected.

## INITIAL COST

Meter and installation for five years.....	\$ 70.00
Supervision and care of meter for five years.....	113.40
	<hr/>
Total cost per meter for five years.....	\$ 183.40
Cost per year.....	36.68
	<hr/> <hr/>

Assuming that a man irrigating handles 150,000 gallons per day and irrigates 200 days a year, he will handle in five years 150,000,000 gallons of water. If the cost per million gallons of water is \$20.00 and a man's efficiency is increased 20 per cent there will be a saving as follows:

150 million gallons of water @ \$20.00.....	\$3,000.00
20% saving for five years.....	600.00
Saving resulting from meter installation for five years.....	\$ 600.00
Cost per meter for five years.....	183.40
	<hr/>
Net saving for five years.....	\$ 416.60
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A 20 per cent saving is assumed to try and meet average conditions. In actual practice, the increase in efficiency was nearer 50 per cent.

## SUGGESTIONS FOR EFFICIENCY IN IRRIGATION

In studying the irrigation problem here, several important phases of the work have stood out very prominently as producing efficiency in irrigation practice. These are:

- (1) Making careful measurements of the water as it goes on the fields.
- (2) Making round reports of the water used per man, the amount applied per acre and the area covered per man day.
- (3) Giving the irrigators, at all times, the maximum amount of water that they can handle efficiently.

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## Hawaiian Agriculture Prior to 1860\*

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COMPILED BY H. P. AGEE

Until the development of the pineapple industry within recent years, the prosperity of Hawaii, as we all know, was largely dependent upon sugar. Some students of agriculture are inclined to question the soundness of such one-crop agriculture. It is of some interest therefore to know from what a diversity of

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\* Read at a meeting of the Social Science Club, Honolulu, November, 1926.

agricultural effort a sugar industry grew, and what a painful process it was, fraught with struggle, discouragement and failure all along the way.

Fortunately, many details of the early agriculture of the Islands are preserved for us in the *Transactions of the Royal Hawaiian Agricultural Society*, which held annual meetings between 1850 and 1856, inclusive. The membership of that organization included progressive, farsighted men. Some of their predictions are remarkably accurate. In laying plans for the future they reviewed the past.

Since so much of the charm of history may be lost when one attempts to change the wording of old documents into language of his own, I shall, for the most part, use direct quotations from the original papers. One of particular interest is the address of R. C. Wyllie, delivered at the first convention of the Society in August, 1850. From it I read:

We are now in a position duly to appreciate the great benefits conferred on the nation by the introduction of seeds, plants and animals, by those who have gone before us.

In running through the pages of Captain Cook, we find the following productions, only, of the Islands seventy-two years ago, viz:

Taro of large size and fine quality.

Sweet potatoes, from 12 to 14 pounds each.

Plantains, five or six varieties.

Bread fruit; scarce.

Yams; scarce.

A sweet root like a yam in form; probably the root of the ti plant.

Sugar cane of large size and good quality.

Cocoa nuts.

Ava root.

Gourds.

Fowls; scarce.

Hogs; abundant.

Dogs; used as food.

Geese.

Large white pigeons.

Fourteen years afterward, or fifty-eight years ago, when Vancouver visited the Islands, we find that the following were the only new productions, viz: Goats, Water Melons, Musk Melons.

Since those days the productions of the Islands have become wonderfully multiplied, and their wealth has increased in proportion. I have taken some pains to learn to whom the Islands are indebted for this great and beneficial change. They are as follows:

1. The discoverer, Capt. Cook, who, on Sunday, the first of February, 1778, left on the Island of Niihau, one ram goat and two ewes, a boar and sow of English breed, and the seeds of melons, pumpkins, and onions.

2. Captain Colnet, who left a ewe and a ram on Kauai, before the arrival of Vancouver.

3. Captain Vancouver, who, on Sunday, the fourth of March, 1792, left to Tianna on Hawaii, some vine and orange plants, some almonds and garden seeds, and to Keaumoku (the father of Kaahumanu) a goat and kid, some fine orange plants and garden seeds. On the 13th of March, 1792, he left to the young Prince Kaumualii, of Kauai, a male and female goat and two geese; on the 25th February, 1793, he left to Keaumoku, before mentioned, one ram, two ewes and one ewe lamb; on the 19th February, 1793, he landed a bull and cow from California, for Kamehameha I, in the canoe of Krimamahoo, off the coast of Hawaii; on the 22nd of February, 1793, he landed five cows, two ewes and

a ram, in the bay of Kealahkekua, for Kamehameha I; on Tuesday, the 5th of March, 1793, he landed in the same place, for the King, a variety of culinary utensils, implements of husbandary, smiths' and carpenter's tools; on the 17th of March, 1793, he presented a large assortment of useful tools, implements and household utensils, and some goats to the king of Maui; on the 28th of March, 1793, he presented a complete set of armorer's tools to Enemo, the ruling chief of Kauai; on the 15th of January, 1794, he landed a bull, two cows, two bull calves, five rams, and five ewe sheep, from California, in Kealahkekua Bay, for Kamehameha I.

4. Don Francisco de Paula Marin, who came to the Islands at a very early period (it is believed in the *Princesa Real*, in 1791), and who appears to have served the King in many capacities. His journal, kept in Spanish, and consisting of several volumes, is in my possession. The volumes are much dilapidated, and as the first entry is dated 14th November, 1809, there is reason to believe that several volumes have been lost. I have hastily extracted the following particulars from his journal:

On the 11th of January, 1813, Marin says he had planted at sundry times, some pine apples and an orange tree, beans, cabbages, potatoes, peaches, chirimoyas, horse radish, melons, tobacco, carrots, asparagus, maize, fig trees, lemons, lettuce, and that he had been engaged in making kukui oil, cocoa nut oil, candles, tiles, hay, cigars, and had acted in the several capacities of butcher, cook, mason, ship carpenter and physician;

On the 27th of June, 1813, he was engaged in making nails;

On the 24th of February and 1st of March, 1815, he was engaged in planting vines for the King;

On the 6th of July, 1815, it is recorded that he made 38 gallons of wine;

On the 13th July, 1815, that he made five flasks of brandy;

On the 7th of December, 1815, that he made a barrel of beer;

On the 30th of December, 1817, there is a record that he planted coffee, cotton, made lime, planted cloves, salted pork, made pickles, planted tomatoes, turnips, pepper and chilis, sow'd wheat and barley, made castor oil, soap, molasses, syrup of lemon juice, planted saffron, cherries, and made shirts;

On the 25th of February, 1819, he was engaged in making sugar;

On the 15th of April, 1819, that he was sent for to cure the King, with whom he remained till the 8th of May, when he says, the King died, aged 60 years and 6 months;

On the 18th of May, 1819, that he was repairing muskets;

On the 27th of August, 1819, that he was selling vegetables for the King to the French sloop of war "*Descubierta*;"

On the 14th of September, that he was making extensive purchases from vessels, for the King.

On the 22d of September, 1819, he says: "This day they brought me the first orange, though I planted the seeds eight years ago."

On the 4th of November, 1819, that he was engaged bartering sandal wood for rum;

On the 8th of December, 1819, that he received the commission of Captain, which commission is still extant;

On the 14th of March, 1820, he records, "this day arrived the brig of middling size, called the *Thaddeus*, Capt. Blanchard, bringing missionaries for these Islands."

From this brief account of the labors of Don Francisco de Paula Marin, from 1809 to 1820, few of you will doubt that much of the present wealth of the Islands, is owing to seeds, roots, and plants introduced by that one man. In my own opinion, it may be fairly questioned if there existed on these Islands, or exists at present, any man, to whom the Hawaiian people are generally so much indebted. His surviving children, therefore, are well entitled to the favorable consideration of the King's Government.

It is true that Marin was more frequently engaged in distilling brandy, rum and beer, than I have thought it worth while to record. But, nevertheless, he seems to have been, upon the whole, a temperate man, for, from 1809 to the 14th of March, 1820, he only records that he was drunk on three occasions, on one of which they had to carry

him home. If he had been oftener drunk, I have no doubt he would have mentioned it, for his journal is singularly minute in regard to his private habits, and those of the King and the ladies of his family. It is due to his memory to mention, that amongst his papers were found some ancient translations into native of the Lord's prayer, and other prayers used by the Catholics, from which it is to be inferred that he had made some effort to abolish the native idolatry.

It will be noted that Marin told that he made sugar on February 25, 1817. This is one of the earliest records of sugar making, but not the first, for there is evidence, but not positive proof, that sugar was made on Lanai in 1802. Of this and some other early endeavors Thrum, in his *Annual* for 1875, says:

There are many localities laying claim to the first mill, and as many claiming the credit for the establishment of this industry, which has long since been the leading one, that it has been no easy task to define its legitimate founder. After examination through all the early publications of the Islands for definite authority and a starting point, the only information thereon is found in a paper read by the late L. L. Torbert before the Royal Hawaiian Agricultural Society, in January, 1852, wherein he states that "the earliest sugar manufacture was in 1802, by a Chinaman, on the island of Lanai, who came here in one of the vessels trading for sandal wood, bringing with him a stone mill and boilers, and after grinding off one small crop and making it into sugar, went back the next year with his apparatus." Mr. Torbert gave as his authority, John White, who arrived at the Islands in 1797, and who, from his constant travel back and forth in the retinue of the chiefs, had ample opportunity to learn of the time and place of the new industry.

The fact of Mr. Torbert giving credence to the above, and his presenting the same before the Agricultural Society, is proof sufficient in the minds of many that the same is correct; yet there are a large number who place no reliance on the statement, and look to a later period for its establishment.

As before stated, various localities lay claim to the first established mill, or more properly, the first manufacturing of sugar, for sugar and molasses were produced before the establishment of a mill.

Don Paulo Marin recorded in his journal of making sugar in Honolulu in February, 1818, but no allusion other than this is made thereto.

Sugar was made in Honolulu about 1823, by Lavinia, an Italian, who had the cane pounded or mashed on huge wooden trays (poi boards) by natives with stone-beaters, collecting the juice and boiling it in a small copper kettle. About this same time Antone Catalina is also claimed by some to have been the founder of the industry by making excellent syrup at Waikapu, Maui—the site of the present Waikapu Mill—and Jungtai, a Chinaman, is said to have established the first mill at Wailuku.

Various accounts agree as to the manufacture of sugar and molasses being entered into quite generally about this time (1823-4), though doubtless with the view of rum making, which was then carried on extensively.

Stephen Reynolds, in a paper entitled "Reminiscences of Hawaiian Agriculture," read before the Royal Hawaiian Agricultural Society, in 1850, gave an account of the first serious attempt to start a plantation. This paper reads:

Coffee plants were introduced by Lord Byron in the "Blonde" in 1825. If the plant had been introduced here before, it had become extinct. These plants were taken on board at Rio Janeiro.

In an agricultural and commercial view, cane and coffee are most important—for food, the Kalo. Experience has proved thus far that the soil and climate are favorable to the coffee tree, to the growing of cane and manufacture of sugar.

The first enterprise to any extent to start a plantation on these Islands, was undertaken by Mr. John Wilkinson, who came from England under the patronage of Governor Boki, when Lord Byron in the "Blonde" brought Governor Boki and his party back to the Islands, and the remains of the King and Queen who died in London.

Mr. Wilkinson had made partial arrangements with Governor Boki while in England, to be completed here. Manoa valley was selected as an eligible situation, and a suitable soil for a coffee and sugar plantation. The documents were made out and operations began. Mr. Wilkinson, unfortunately, had but small funds which were soon expended. He began on a large scale—laid out a large garden in a most fanciful and tasteful manner. He commenced operations in July or August, 1825. Every kind of farming utensil was wanted—not to be had—to carry on so great an undertaking. Carts, ploughs, hoes—all were very scarce. Expedients had to be resorted to. The land was mostly prepared by natives with the oo or digger, a long and costly process, for a speedy operation. Labor at 25 cents per day soon exhausted the planter's funds. He was sickly, and died March, 1827. He had more than one hundred acres of cane growing when he died. Governor Boki was desirous to save it. Mr. Wm. French, John C. Jones, Esq., John Elbets and myself took an interest in the plantation. After the first cutting, the plantation dilapidated and wasted away for want of protection. The coffee trees were left to grow without care or attention. Small parcels were picked by the natives, a pound or two at a time. Whether the same trees are still growing I do not know. Alexander Adams planted some slips in Kalihi valley that produced excellent coffee. Also at Niu, a valley beyond Diamond Hill. Rev. Joseph Goodrich introduced coffee plants at Hilo, which grew luxuriantly. There were two kinds, the large white and the dark berry—similar to that now cultivated at Hilo. Some plants were introduced on the west side of Hawaii, which grew and produced largely, demonstrating most clearly that it was well adapted to that part of the island. The plantations of Mr. Charles Titcomb, and Mr. Godfrey Rhodes, on the island of Kauai, give complete evidence that coffee of superior quality grows on that island, yielding large crops.

Again turning to Mr. Thrum's paper previously mentioned, we read:

That the various sugar mills so far were but small and primitive, and the cultivation of cane but little attended to, may be inferred from there being no notice made thereof, and on this account, perhaps, our historian, Jarves, did not touch upon this subject in his history of the Islands, though he had ample means in his day (1840) of learning the full facts of its origin and growth.

In view of the foregoing facts, we must, without doubt, give credit to Messrs. Ladd and Company, for the bona fide establishment of sugar manufacture, who, in 1835, secured a grant of land at Koloa, Kauai, from the Government, for silk and sugar culture.

It is to Dr. R. W. Wood that we owe a detailed account of this enterprise. The Royal Hawaiian Agricultural Society had asked him to give an "Historical Account of the Introduction and Progressive Culture and Manufacture of Sugar in these Islands." Pleading lack of time and necessary data he confined himself largely to the single plantation at Koloa:

It is known to most of the older residents, that about the year 1835, a mercantile house in Honolulu obtained, with no little difficulty, a grant of land, on the Island of Kauai, for the purpose of establishing a sugar plantation. Previous to this period some attempts had been made to introduce this branch of industry, but that which has been already alluded to by Mr. Reynolds, is the only one deserving of notice, and that not promising to be productive, was soon abandoned. That on Kauai was the first enterprise of any magnitude of this kind, on the Sandwich Islands. For a period of six years subsequent to its commencement, its failure continued to be confidently predicted by the more intelligent portion of the foreign community.

On this plantation the ground was first broken by a plough drawn by natives. There were no working cattle at that time upon the Island. Wild or indigenous canes, abundant in the vicinity of Koloa, after three or four months persevering resistance of the prohibition of use imposed upon them by the Chiefs of Kauai, were collected, and a nursery commenced. From the first crop of cane obtained, the proprietors succeeded in producing molasses or syrup only. The following season they succeeded in producing sugar, but of inferior quality, and the sugars produced from that estate previously to the year 1842, would now be considered scarcely merchantable.

Previous to the year 1840, two mill sites were abandoned, and the entire works, including buildings, machinery and furnaces sacrificed. A third mill was erected in 1841, which, with improved works, enabled the proprietors to increase considerably the products of their estate, with however but very little, if any, improvement in the quality of the sugars manufactured.

About this time a French gentleman, M. Provost, who had had considerable experience in the manufacture of sugar in the Isle of Bourbon, was engaged upon the estate for the period of one year. In consequence of the improvement introduced by him in the tempering, clarifying, boiling and granulating of sugars, their quality was greatly improved, and their value increased. Previous to the year 1843, in the absence of purchasers, and for the want of nearer markets, the proprietors were under the necessity of shipping, on their own account their sugars, to Valparaiso, Sydney, and the United States, and they sustained by these operations, a loss of some thirty thousand dollars. Since the year 1843, very little, if any, advance has been made in the improved quality of sugars, although the aggregate quantity produced upon the Islands, has been yearly increasing. Although the present mode of conducting its manufacture is of great improvement upon the rude and unskillful attempts of the pioneers in this branch of industry, yet, owing to the want of better constructed works, and of more skill and experience in constructing them, the business is still prosecuted under comparatively great disadvantages. And thus far the Sandwich Island planters, have been less indebted for their success, to the efficiency of their mills and boiling houses, than they have been to the excellent adaptation of soil and climate to the culture of the cane, to the proximity of good markets, and especially to their exemption from competition with more systematic and skillful manufacturers. In proof of this assertion, I need but refer to the statement made by Mr. Parsons, that it has been ascertained, by a nice calculation, that on a plantation on Maui, the cost of growing was about twelve dollars, and that of manufacturing fifty dollars per ton; which in Demerara, the East and West Indies, the cost of growing and manufacturing is considered about equal. It is true that in some of these countries, especially Demerara, where the land requires to be drained by canals intersecting each other in every direction, and where only the spade and hoe can be used, the culture of cane is attended with more expense, than it is in the light mellow soil of these Islands. Still the cost of manufacturing ought not much to exceed that of growing the cane.

Concerning subsequent endeavors, Thrum says:

Notwithstanding the difficulties under which this plantation was working, and the prophecies of many for its failure, it gave an impetus to others in various parts of the Islands, for in 1838 there were in operation, and about to be erected, twenty mills by animal power and two by water power.

Previous to 1841, probably 1839, Governor Kuakini, of Hawaii, had a few fields of cane planted at North Kohala, about 75 or 100 acres in extent, with the expectation of a contract with some foreigner for grinding.

In 1841 thatched buildings were put up in Iole, Kohala, by the Governor, in pursuance of an agreement with Aiko, a Chinaman, who had previously followed the sea in some capacity under Capt. Brewer. Aiko himself followed immediately and put up his mill—upright wooden rollers, 18 inches in diameter, by two and one-half feet high bound with iron,—and an over-shot water wheel for motive power. The planting was done by

contract with natives in the old style, i. e., with an oo, digging off the grass and making the least bit of a hole possible for the seed. Labor was cheap and paid for in goods. Brown cotton at \$1.00 per pio (3 yards) and blue cotton and prints at \$1.50 for the same quantity.

The products of the mill were laboriously carted over the hills to Mahukona where they were shipped to Honolulu. The carts were very heavy and the wheels were cross sections of koa logs. The wear and tear therefore of oxen and carts over the rocky road were very great. Nevertheless the proprietor was successful in making money and would have remained, but the heir of Governor Kuakini so increased the rents of lands and other charges that he threw the whole thing up in disgust and left for Hilo, where he carried on a plantation with success for many years, and where he now resides.

Before leaving, however, he sold out his plantation to an invalid Chinaman. The latter deceased soon after and the establishment came back upon Aiko's hands and he returned, ground the last crop, and definitely closed up the business in 1849 or 50.

Up to 1843, Hawaiian sugars did not enjoy a favorable reputation abroad, partly from the low grades, but more from the injudicious desire of many producers to realize all possible. Sugars were shipped imperfectly cured, and in several cases all the refuse was added thereto that could be collected from the drying-houses; nor was our reputation thoroughly established for good merchantable sugars until after the establishment of the Royal Hawaiian Agricultural Society in 1851, when their attention was called to the fact, and their influence sought thereon.

The first notice made of any exportation is for the year 1837, when 4,286 lbs. sugar and 2,700 gals. molasses were exported. A regular table from this point being valuable and interesting, we have compiled the following, but as this was prior to the establishment of Customs' regulations at these Islands, the figures we have are from merchants published statements and are not fully complete—as the notings herewith show:

#### YEARLY REPORTS OF SUGAR AND MOLASSES FROM THE HAWAIIAN ISLANDS SINCE 1837—ITS FIRST YEAR OF EXPORTATION

Year	Sugar pounds	Molasses gallons	Year	Sugar pounds	Molasses gallons
1837 .....	4,286	2,700	1856 .....	554,805	58,842
1838 .....	88,543	11,500	1857 .....	700,556	48,486
1839 .....	100,000	75,000	1858 .....	1,204,061	75,181
1840 .....	360,000	31,739	1859 .....	1,825,620	87,513
1841 .....	60,000	6,000	1860 .....	1,444,271	108,613
1842 .....	.....	.....	1861 .....	2,562,498	128,259
1843 .....	1,145,010	64,320	1862 .....	3,005,603	130,445
1844 .....	513,684	27,026	1863 .....	5,292,121	114,413
1845 .....	302,114	19,353	1864 .....	10,414,441	340,436
1846 .....	300,000	16,000	1865 .....	15,318,097	542,819
1847 .....	594,816	17,928	1866 .....	17,729,161	851,795
1848 .....	499,533	28,978	1867 .....	17,127,187	544,994
1849 .....	653,820	41,235	1868 .....	18,312,926	492,839
1850 .....	750,238	129,432	1869 .....	18,302,110	338,311
1851 .....	21,030	43,742	1870 .....	18,783,639	216,662
1852 .....	699,170	62,030	1871 .....	21,760,773	271,291
1853 .....	642,746	75,769	1872 .....	16,995,402	192,105
1854 .....	575,777	68,372	1873 .....	23,129,101	146,459
1855 .....	289,908	38,304	1874 .....	24,566,611	90,060

These figures are from January to August only, while for 1841 the figures are from August, 1840, to August, 1841. No figures for 1842-1843, but the figures of the following year doubtless include both.

Sugar, its culture and manufacture, received considerable care and attention from the R. H. A. S., and doubtless, as much the object of its being brought into existence, as anything else was, to devise ways and means to promote this industry, as the published papers of the Society will show. That it has done so is plainly to be seen, for immediately following is noted an improvement in cultivation, grinding, boiling, draining, packing, etc., to say nothing of the increased interest taken in it and the impetus it received thereby from many who had been giving their attention to the whaling interests.

In a paper read before the Society in January, 1852, by the late L. L. Torbert, he stated that "cane grew without culture, almost anywhere on these Islands, as high as 3,000 feet. At 1,700 feet above the sea it ceases to blossom and continues to grow on from year to year for four, five or six years. How long it will grow on the same spot without exhausting the soil would be hard to tell, as he knew of a field, that according to the tradition connected therewith, must have been one hundred years old, and bid fair to produce equally good canes as many years hence. In some soils it may degenerate and die out, while in others it improves by long standing.

During the season of 1851, the first centrifugal drying machine was put in operation at the East Maui Plantation. Previously all sugars were dried by the old and tedious process of draining from boxes or barrels, through holes bored to allow the molasses to drain off, leaving it but imperfectly or unevenly dried after all. The centrifugal gave such universal satisfaction through the improved grades of sugar and the saving of time, that it made a thorough revolution in our sugar industry, for every planter, large and small, changed as fast as their orders could be filled.

The sugar interest suffered severely this year from an unprecedented drought, and was further checked by low prices on the Pacific Coast and the establishment of duties. These combined causes resulted in a great falling off in product, as we find but 21,030 pounds exported for 1851, the smallest amount since the first year of its exportation, and the tables up to 1855 show an unsteady yield, partly from the above causes and the inefficiency of labor, but after which the total yearly product has shown a steady gain.

Scarcity of labor was seriously felt on nearly all the plantations, but more especially on those of Kauai and Maui, and an effort was made to meet the difficulty by the importation of coolie labor from China, in 1852, to work under contract for five years. This for a time gave relief, but did not come up to expectations, for when working with the natives there were continued jealousies, and when their time was out they preferred to enter the trading or domestic service, to renewing a plantation contract. Labor was a vexed question in 1851, and it has continued to be so ever since.

An account of the first attempt to import Chinese labor is given in the report of the Committee on Labor at the 1851 convention of the Royal Hawaiian Agricultural Society. It reads:

A contract was entered into in the month of September, 1850, with G. F. Hubertson, Esq., a merchant recently established here (who had resided in China, and was supposed to be the best person with whom to make the contract, from his experience in the matter, and his facilities), for the importation of two hundred Chinese coolies. The charge for the passage for each coolie was fifty dollars, which with the advances to be made to each, on shipping them, and a year's supply of rice for consumption here, made the sum about \$71 that each coolie would cost delivered here, of which two months' advance wages formed a part. The men were to be engaged for five years. To secure dispatch in this matter between nine and ten thousand dollars, or nearly two-thirds of the whole amount was advanced to Mr. Hubertson to meet the ship's disbursements in China and the necessary expenses of shipping the coolies. The ship *Amazon*, belonging to Mr. Hubertson, sailed on the ....., and your committee believed that a successful commencement had been made of the great work to supply the islands with laborers, whose brawny arms should lay open to them the wealth now buried in its soil. But we were

sadly disappointed. The Amazon arrived in China, and the coolies, we learn, were engaged, but after waiting in vain for her return with the much needed freight, a rumor has reached us that the vessel has been sold and the voyage abandoned. The reasons for this disastrous result have not been made known to us, and in the absence of Mr. Hubertson we must probably for the present remain in ignorance of them.

Arrangements have since been made by members of this Society to produce coolies, with Capt. John Cass of ship *Thetis*, which vessel sailed yesterday for Amoy, for that purpose. This new enterprise your committee believe will be successful, and that we shall soon be able to try an experiment, the success of which will remove the grand obstacle to our agricultural progress and success.

In the first part of the same report an interesting reference is made to steam, the great new motive power which was yet to be made use of in the Islands:

That great auxiliary to, and substitute for, the labor of human hands, which is now lending its giant aid, not only to the mechanic and the manufacturer, but also the planter and the farmer, is as yet unknown among us. Not a steam engine is to be found upon these islands, and even the occasional visits of the "moku ahi," or fire-vessel, are yet hailed with wonder and admiration by the natives, and as "remarkable events" by the foreign class of our population. Doubtless this mighty agent will ere long be introduced and put in successful operation, but the present obstacles, the lack of capital, the want of machine shops, difficulty of obtaining engineers, and the scarcity of fuel, appear so formidable that no one as yet has the courage to face them.

The following year the report of the labor committee read:

Labor has been a subject of much anxiety with planters on the different islands. The planters had long foreseen that laborers would have to be brought from foreign countries; their anticipations were now matters of fact. Sugar plantations find it difficult to engage natives for any long term of time, a few only are willing to engage for more than three to six months. Importation is the only reliable source for permanent labor. Importation has commenced, and thus far promises to be satisfactory. Since our last meeting, the ship *Thetis* has arrived from Amoy, China, with about two hundred coolies, which were distributed among the planters, as by contract entered into with the master, John Cass, before sailing from Honolulu.

They have proved thus far diligent, but not swift; obedient, but require looking after. Planters have different views as to the relative value as laborers between coolies and natives. Some think four coolies equal to five natives, in amount of labor; others reverse the matter by placing three natives against four coolies. On the plantation of H. A. Pierce & Co., there was some apparent jealousy by the natives when the coolies first arrived among them. At Koloa, some little skirmishing at first, but it soon subsided; peace and harmony soon produced the kindest feelings. The coolies are far more nice in doing their labor, of which they feel a pride over the natives, calling them "Wahine! Wahine!" (Women! Women!). On Dr. Wood's plantation coolies are considered far superior laborers to the natives, they perform more work, and do it better and handsomer.

The wages of the cooley is, by contract, three dollars a month, then the passage from Amoy, advance wages, and outfit, amount to nearly four dollars, which added to the wages make nearly seven dollars, this sum includes the board on the plantation. Natives have six dollars a month and find themselves.

Further developments in attempting to establish the industry are taken from Thrum:

Up to 1857 we notice the struggle of this industry to be one of hardships and disappointments. The Lihue estate, after an expense of \$7,000 in digging a canal to enable

them to convey water for irrigating their fields, had now but the prospects of a change in the result of their labors which for five years had yielded nothing but disappointed hopes.

At this time the number of plantings had dwindled down to five, consisting of the Koloa and Lihue on Kauai, which were run by water (Lihue having steam to use as an auxiliary); East Maui and Brewer plantations on Maui worked by mule power, and one on Hawaii near Hilo, by Chinese (Aiko), run by water power.

These were followed during 1857 by two new ones in or near Hilo, one by Samsing and Company, and the other by Utai and Company, Chinese merchants of Honolulu.

The next extension we find to be in the latter part of 1858, when the Makee and Haiku plantations of Maui and the Metcalf plantation of Hilo were laid out.

Our planters, ever on the watch for improvement, turned their attention, about 1858 or 1859, to steam as the motive power in sugar making, when the Haiku Plantation was established with steam for grinding, boiling, and finishing, and commenced its operations in the season of 1861-2. Another stride for improvement was in the introduction of vacuum pans for finishing, the first of which was put in operation at the Kaupakuea Plantation, in 1861, and the year following one was set up at Lahaina. The mode of sugar boiling on all the plantations, was, with these exceptions, by the open train, and while our large planters were seeking to improve their works by the addition of steam strike pans, vacuum, or wetzel pans, the number of small planters were increased by the advent of the sorghum pan, which allowed many to start operations on account of the small amount of capital required for commencement.

The number of plantations in operation at this time (1861) were twenty-two, of which nine used steam as the motive power in grinding, twelve were driven by water, and one by animal power.

About this same time an effort was made by a joint stock company towards the establishment of a sugar refinery in Honolulu, which commenced operations the following year, but after a struggle of six years or so it closed its doors, never having done more than manufacture sugar from the molasses from the plantations and drain the pockets of its stockholders.

We have now reached 1861, and I set out to tell you of agriculture in Hawaii before 1860.

I trust that from the quotations I have made from these old papers that I have given you a better understanding of what it meant to be "in on the ground floor."

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## Exotic Trees in Hawaii

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BY H. L. LYON

*Colvillea racemosa*: This is a very showy-flowered, leguminous tree from the South African region, which some observers consider "a worthy rival of the Royal Poinciana," to which tree it is rather closely related.

There is but one species in the genus *Colvillea* and the natural geographical distribution of this species has never been determined. Some botanists have ventured the opinion that it is a native of East Africa, but, so far as we are able to determine, it has never been found in a wild state. It was discovered by the



Fig. 1. *Colvillea racemosa*. A young tree of characteristic form with heavy clusters of pendulous racemes at the ends of the topmost branches. Photo by E. L. Caum.

botanist, Bojer, in 1824, who described it from a single specimen which he found under cultivation by the natives on the west coast of Madagascar. Seed from this tree was planted in Mauritius and the resulting trees have flourished and supplied seed for the wide distribution of the tree throughout the tropics of the world.

The first trees of *Colvillea* to be grown in Hawaii were reared from seed obtained from Ceylon in 1918 by J. F. Rock. The seedlings were grown at the Experiment Station and distributed about Honolulu for planting in public places and in private gardens. A few of these trees have done remarkably well and it

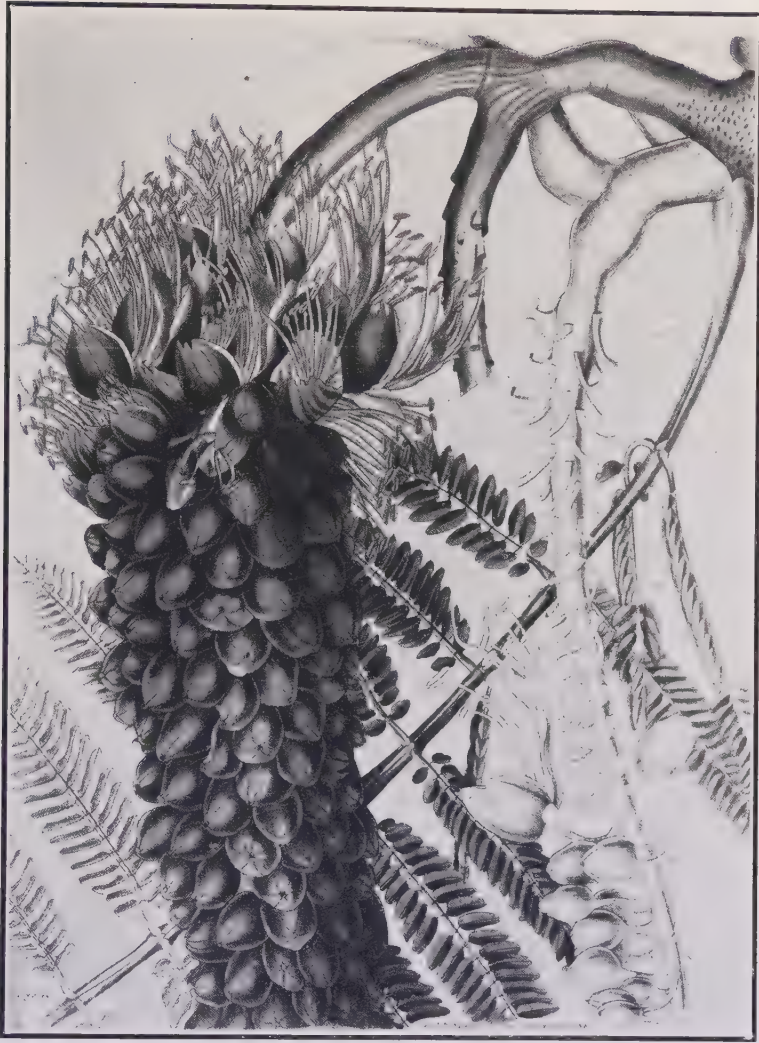


Fig. 2. *Colvillea racemosa*. Portion of a raceme showing buds and open flowers. From a colored plate in Curtis' Botanical Magazine.

now looks as though we can consider *Colvillea* an established plant in the gardens of Hawaii. A specimen in J. W. Waldron's yard in Nuuanu Valley flowered in 1925 and was the first tree of its species to flower in Honolulu. This same tree flowered in 1926, as did also one tree in the Makiki District and two in Kaimuki. The tree illustrated in the accompanying photograph is growing in the Makiki District in Honolulu. This picture shows the growth and foliage characters of the tree and its habit of flowering. Its feathery leaves are bipinnate and closely resemble those of the poinciana, although a careful comparison shows them to be somewhat larger and coarser than the leaves of the better-known tree. Its flowers are produced in heavy clusters of pendulous racemes at the ends of the branches. Each raceme carries many closely set buds, the ones at the proximal

end opening first. The buds have a velvety surface and are bright orange red in color. The conspicuous feature of an open flower is its cluster of ten long, bright yellow stamens. The buds are really more striking than the open flowers, so the tree is at its best when the first flowers are about to open. The flowers do not last long after opening. Mr. Waldron's tree set and matured one pod in 1925, but none of the local trees set any pods in 1926.

*Colvillea* is certain to become a popular tree in Hawaii, not because it is more showy than our brilliant shower and flame trees, but because it flowers at a season when these trees are in heavy leaf and fruit. Judging by the few trees which have already flowered in Honolulu, *Colvillea* is going to flower with us in October and November. In Madagascar, it flowers in April and May, but since its habitat in Madagascar is about as far south of the equator as Hawaii is north of it, the flowering period comes in the same season of the year. MacMillan states that *Colvillea* flowers in Ceylon in September and is suited to the moist or moderately dry lowlands.

*Terminalia myriocarpa*: This is one of the most promising forest trees among our recent introductions. It is a native of India, where it is known under the names Jhalna, Hollock and Panisaj. The one and only lot of seed which we have secured to date was collected in Northeastern Assam by J. F. Rock. From this seed, we reared about one hundred seedlings, which were distributed among as many situations as possible. In all places where the behavior of the trees has been followed, they are doing remarkably well. The excellent showing made by a small group of these trees in the wet lands above Pepeekeo on Hawaii is particularly gratifying in view of the fact that the majority of the other species of trees tried out in this region have failed to make any growth at all. A few trees of the Jhalna planted out by the Wailuku Sugar Company in its Waikapu Arboretum, which is located in a very dry situation, are also flourishing, while many of the other trees under test in this Arboretum have succumbed under the frequent droughts.

We planted out eight seedlings of *Terminalia myriocarpa* in the Manoa Arboretum in May, 1922. They immediately assumed, and have since maintained, the lead among the trees of the plantings of that year. An idea of the habit of growth displayed by these young trees may be gained from the accompanying photographs. In general, they suggest rank-growing guava bushes with exceptionally large leaves. From the literature, we learn, however, that they soon assume the habit of an upright tree and eventually attain very large dimensions.

Troup, in his "Silviculture of Indian Trees," pp. 532-534, gives us a very good picture of the tree in the description quoted below:

A very large evergreen tree with pendulous branches. Bark greyish brown, rough, exfoliating in vertical flakes. Wood dark brown, hard, used for house building, canoes, cheap furniture, and other purposes. The tree attains very large dimensions. Mr. Jacob<sup>1</sup> records one tree in the Raidak valley over 30 feet in girth, and two trees close together in the Chirran valley roughly 36 and 27 feet in girth. Babu, R. N. De,<sup>2</sup> records a tree 46 feet 4 inches in girth round buttresses in the Lakhimpur district, Assam.

<sup>1</sup> Report on the Forests of Bhutan, 1912.

<sup>2</sup> Ind. Forester, xlv (1918), p. 517.

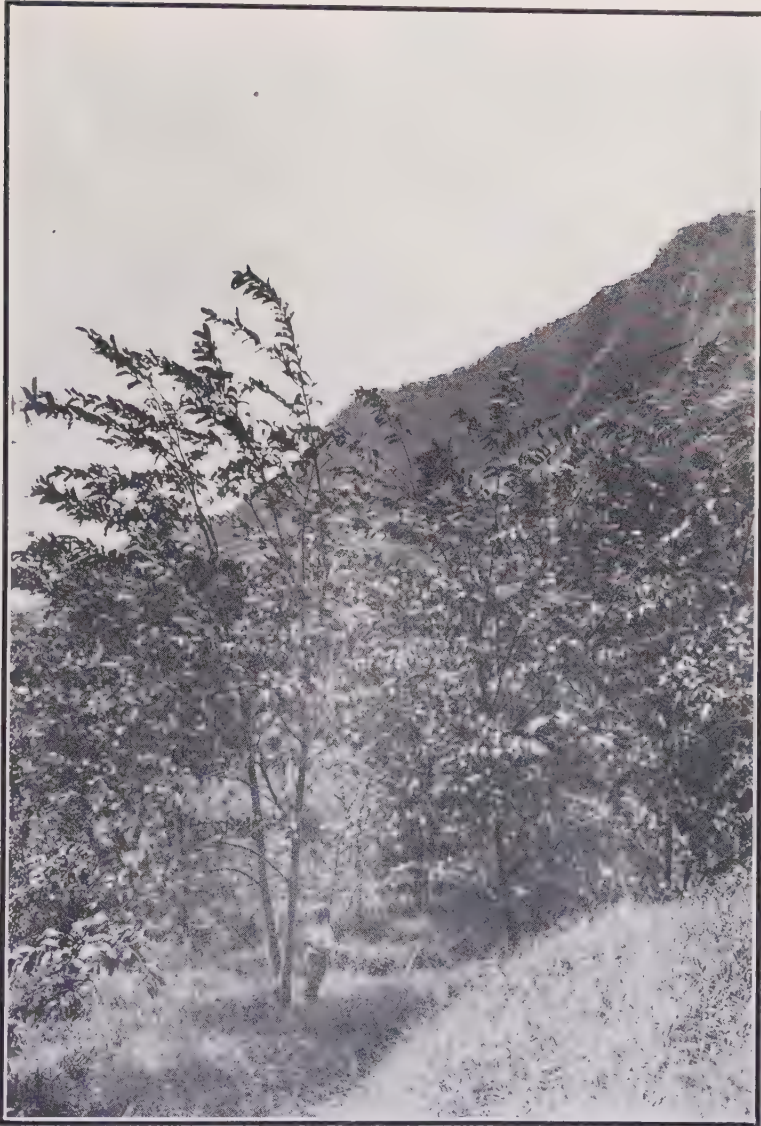


Fig. 3. *Terminalia myriocarpa*. A young tree, five and one-half years old from seed, growing in the Manoa Arboretum. Photo by E. L. Caum.

Eastern Himalaya from Nepal eastwards, in valleys and lower hills up to 5,000 feet, Assam, hills of Upper Burma. It is very plentiful in some localities, often coming up in gregarious patches on newly exposed ground, forming pure even-aged groups underneath which evergreen species appear. Mr. Jacob notes that it is very common in Bhutan up to 3,000 feet and is found up to 4,000 feet. Mr. Milroy<sup>3</sup> reports that in the Abor country it is the predominant tree on the lower hills, where trees of 12 and 14 feet girth are common, and still larger ones up to 18 and 20 feet are not scarce; he adds that although the trees are apt to be short in the bole and much branched a great quantity of clean timber could be extracted from them.

<sup>3</sup> Report on the Forest Resources of the Abor Country, 1912.

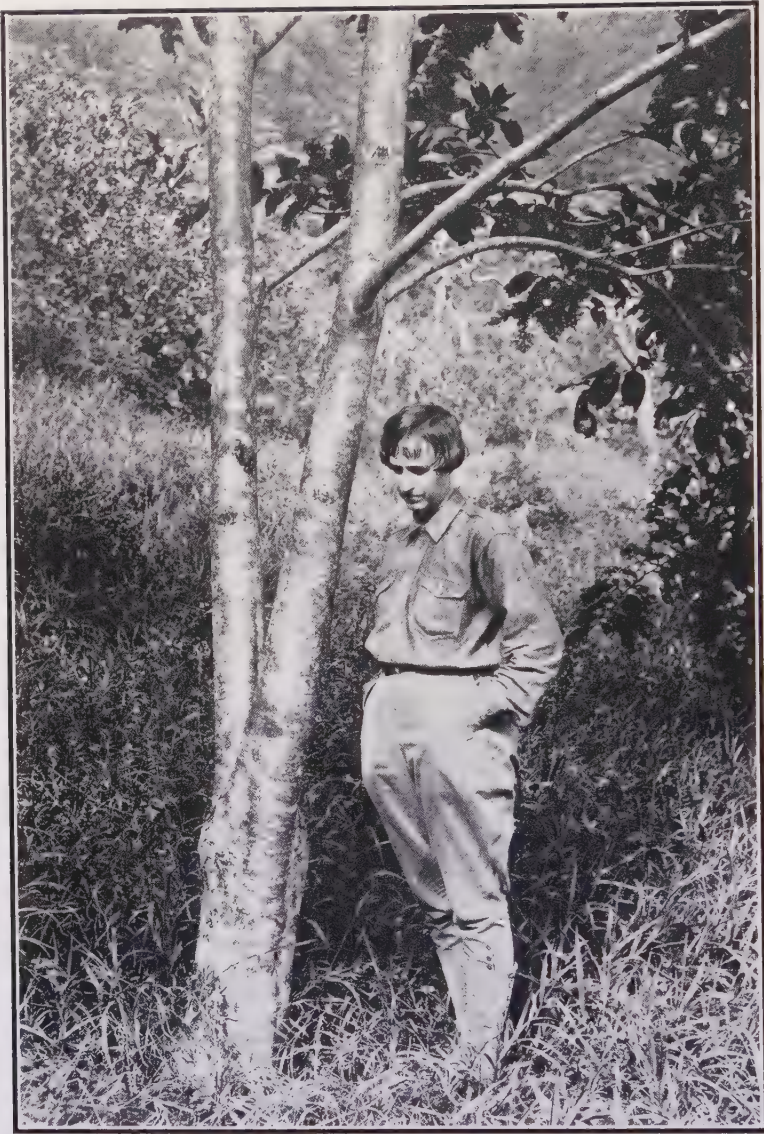


Fig. 4. *Terminalia myriocarpa*. Trunk of the tree shown in Fig. 3.  
Photo by E. L. Caum.

*Terminalia myriocarpa* is essentially a tree of moist situations and rich soil, and in Assam is often found associated with *Bischoffia javanica*. In its natural habitat the absolute maximum shade temperature varies from 90° to 102° F., the absolute minimum from 33° to 45° F., and the normal rainfall from 80 to 200 inches or possibly more.

The panicles of small pink flowers appear in October-November and the fruits ripen from March to June. The fruits are small and light, 0.1-0.15 in. long, light yellowish brown, with a pair of lateral membranous wings, the whole 0.4-0.5 in. in width. About 4,000 to 4,500 weigh 1 oz. The germinative power of the seed is fairly good, tests at Dehra Dun showing a fertility of 63 per cent, which for a small light seed is not unsatisfactory. Seed-year records show that the tree seeds well as a rule every year. The trees are a very handsome sight when covered with masses of pink blossom or yellow fruits.

In its early stages the seedling is minute, and is apt to be washed away by rain before it gains a footing. It develops rapidly, however, and attains a height of about 4-8 in. or more by the end of the first season. As in the case of *T. tomentosa* and *T. Arjuna*, the young plant has a tendency to produce long straggling branches in place of a definite leader, but in spite of this its height-growth after the first season is rapid. Sixteen plants grown at Dehra Dun had a height of 4 ft. 8 in. to 7 ft. 3 in. by the end of the second season, and 10 to 15 ft. by the end of the third season.

The tree bears a fair amount of shade and is exacting as regards moisture. It is not known to produce root-suckers.

The ideal conditions for successful reproduction are a loose porous soil free from weeds, in order to enable the small light fruit to reach the soil and the germinating seedling to establish itself quickly, and a fair amount of soil moisture. The light fruits tend to be washed into heaps and the minute seedlings are also liable to be washed away, considerable mortality resulting. The young seedlings are apt to dry up if exposed to the sun, and benefit by a certain amount of shade; they are also apt to die off in quantity on stiff water-logged soil, and good drainage appears to be necessary for their establishment. The young crop often tends to come up gregariously, where conditions are favorable, on newly exposed ground or fresh alluvium.

Direct sowings are unsuitable, as the small light fruits are liable to be washed away. Experiments at Dehra Dun showed that the best results are attained in fine porous sandy soil in boxes or in well-raised beds protected from sun and heavy rain; watering should be frequent but light. Germination ordinarily starts in two or three weeks and may continue for about three months. The plants transplant well during the first rainy season when 3 to 4 in. high.

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## Rains Remove Twenty Times as Much Plant Food as Crops\*

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Old mother earth's annual bathing bill costs the farmers of the United States more than \$200,000,000 every year. Rain water scouring the countryside, rushing down hillsides, gouging out gullies, and sweeping over gentle slopes of cultivated fields, carries away to the ocean many millions of tons of soil. With this rich topsoil goes 126,000,000,000 pounds of plant-food material—lost to the farmers of the country forever—twenty times the amount permanently removed by cropping.

But this is only a fraction of the damage wrought, says H. H. Bennett, soil scientist of the United States Department of Agriculture. The real scourge of erosion is that it takes not only the elements of plant food but soil—plant-food material and all—leaving in many instances infertile material very difficult to till. Erosion is constantly shaving off the topsoil of cultivated fields—the richest soil of the land. In one instance it was found that 7 inches of topsoil were removed by sheet erosion in 24 years from a gently sloping field of Putnam silt loam growing corn under ordinary cultivation in Missouri. Soil scientists agree that most of the worn-out lands of the world are in their present condition because much of

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\* *The Journal of Heredity*, 17:430, 1926.

the surface has been washed away, and not because they have been worn out by cropping.

A single county in the Piedmont region was found by actual survey to contain 90,000 acres of land formerly productive but now permanently ruined by erosion. Another county in the Atlantic coastal plain has 60,000 acres of land, formerly cultivated, permanently destroyed by rainwash. Much of this could have been saved by timely terracing.

There is need at once for a nationwide awakening to the evils of erosion, says Mr. Bennett. There is immediate need also for fundamental soil data relating to erosion; demonstrations of the value of properly built terraces; and much national education about this menacing agency of land devastation.

[H. L. L.]

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## Forest Destruction and Its Effects\*

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The question of the action of forests on rainfall has been debated by foresters, agriculturists, engineers, and others for a long period, the discussion probably dating back to the time at which scientific forest conservancy was first introduced. In the tropical and subtropical parts of the world this is not, however, the point of primary importance. The vital factor for the community at large is the determination of how far the destruction of forests in catchment areas and on the sides of hills and mountains in the drier parts of a country affects, in the first place, the level of the water in the big rivers, a matter of extreme importance when the rivers are utilized for irrigation or power works; secondly, the decrease in the local water supplies and in local precipitations upon which the cultivator is dependent; and, thirdly, erosion and avalanches, and the destruction they cause in the fertile valleys beneath. Sudden floods may also cause enormous damage to railways, towns, and so forth. In India, which was the first part of the British Empire to give consideration to this aspect of the forest question, the matter has been the subject of discussion and reports through the whole of the past century, a statement which will perhaps come as a surprise to many in Great Britain.

The problem of affording protection to forests for the above causes alone is by no means new. In France and Germany special laws for the protection and extension of the forests and the protection of agricultural lands by means of the forest have long been in operation; and similar laws exist in the Italian States. So far back as 1475 the subject attracted the attention of the famous Venetian Council of X., by whom a law was passed on January 7 of that year, regulating in great detail the clearance of the forests on terra firma. The mountain forests especially were protected by judicious regulations, which were renewed from time to time down to the very year of the extinction of the old republics. Tuscany and the Pontifical Governments were equally provident.

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\* *Nature*, 119:37-39, 1927.

History has since shown that the wholesale destruction of forests in Spain, Italy, Sicily, Greece, and Macedonia has resulted in a great deterioration of climate over considerable tracts, due to loss of moisture, the sterilization of the soil, and excessive erosion.

Although now well known, the chief action of the forest may be stated briefly as follows: The great factor in mountainous and hilly country is the maintenance of tree growth on parts of the area. In the case of bare slopes the rain rushes rapidly down, causing erosion, only a fraction percolating into the soil, and is carried rapidly away, giving rise to spates and perhaps to serious floods, since the old channels of these streams or rivers are no longer able to carry the excess water of flood levels. A hot sun bursting out onto the slope after the rain quickly dries up the thin layer of moisture covering it. In the hotter parts of the globe subject to heavy rainstorms or monsoons the rushing water starts gullies which eventually become ravines, all surface soil is rapidly washed away, and in the course of years the hillside is eaten into, rubble and boulders being sent down to cover up valuable lands below. When the area is under trees, a portion of the rain, falling on the crowns, drips slowly down onto the layer of humus beneath and sinks into it. The larger portion, perhaps, falls direct onto the forest floor, where it is gradually absorbed in the soft covering which takes it up as a sponge. The water then percolates slowly downwards, filling up springs and underground reservoirs, and reaches the streams in a retarded manner. The flow in the latter is consequently more even and regulated, as also the amount of water which eventually reaches the rivers. The latter can therefore be more depended upon to maintain a normal level when it is required to utilize them for irrigation or power works. The roots of trees protect the surface by holding up the soil, and thus directly prevent denudation.

It is possible to give some concrete examples of the effects of the destruction of teak forests in India during the first half of last century, owing to the large demands for this timber from rapidly expanding markets.

The slopes on the west coast of the Bombay Presidency were once, even in the early days of British occupation, covered with magnificent, valuable, and extensive teak forests. These have long since been cut out, some disappearing for good. The denudation of the Deccan Highlands and the Eastern Ghats has resulted in excessive erosion and the gradual silting up of the rivers. When the Dutch, French, and English first built settlements on the Coromandel Coast, it was possible to take ships up the Godaveri and Kistna. The English port of Narsapur and the French one of Yunaon, both on the Godaveri, were once the chief ports on this coast. They can now be reached only at high tide by small native shallow-draught craft. Last year the present writer had arranged to go down the Godaveri from Sironcha, on the frontier of South Chanda (Central Provinces) and the Hyderabad State, to Rajamundri, as he wished to carry out investigations in connection with the effects of forest denudation on this river. It was early in March, the commencement of the hot weather season only. Inquiries elicited the fact that few rafts were now going down, owing to the extensive sandbanks already drying off in the river, and that even by dugout canoe, delays from stranding on sandbanks would be inevitable. Some hundred years ago this

great river was the chief artery or highroad into the interior. At Masulipatam, Dutch ships used to ride at anchor close up to the port, whereas at the present day even small native vessels have to anchor five miles out in the roads owing to the silting up. Between 1840 and 1850, Dr. Gibson, the first Conservator of Forests in Bombay, drew up a list of the rivers and creeks on the Malabar coast, where on arrival in those parts ships used to ride at anchor, all the creeks having silted up within the memory of men then alive.

Dr. Cleghorn, who afterwards became the first Conservator of Forests in Madras, directed attention to the destruction of tropical forests at the meeting of the British Association in Edinburgh in 1850. A committee was appointed to consider this matter. Dr. Cleghorn submitted its report, which was confined to India, the only country for which information was available, at the meeting of the Association at Ipswich the following year. The report summarized the position, as then known to the few in India who had given attention to the matter, pointing to the great and uncontrolled destruction which was taking place, both at the hands of timber merchants and owing to the careless habits of the native populations, who grazed their cattle at will in the forests and fired them every year in order to encourage the growth of new grass. The indigenous tribes in the hilly country also practiced unchecked shifting cultivation, a practice second only to the lumberer in the destruction of fine forests. Under this method, which was a common habit in Europe in olden times, a patch of good forest is felled and the material burnt in situ; coarse grains are then sown on the clearing. The cultivator then sits down and awaits the harvest. Two or three crops are taken off the area; the weeds then became too strong (as he never troubles to weed) and he moves on to a fresh area. The enormous destruction of virgin forest this practice entails, when practiced for centuries, has to be seen to be credited. Yet many of the tropical and subtropical forests in British Colonies and Dependencies are still subject to this the most pernicious and precarious form of so-called agriculture (as also to over-grazing and firing), the administrations responsible not having yet, apparently, understood the evils which attend it. The difficulties facing these governments in prohibiting the practice or controlling it were all experienced in India, in one form or another and overcome.

The encouragement given to the growth of tea and coffee and similar crops by British administrations in the Empire, whilst eminently praiseworthy if carried out on well-considered lines, has been productive of great harm in the past, and even the present day can scarcely be said to be free from anxiety on this score. In a report written in India in 1876 with reference to coffee planting, the following criticism is made:

The planters who come over from Ceylon are now giving a very high price for land, and the whole mischief may be effected in a very short time. It must not be supposed that coffee is at all a permanent cultivation; we have only to look at the Sampajee Ghat in Coorg, the Sispara Ghat in the Nilgris, and parts of the Annamalais to see at once that it is very often very little better than the shifting cultivation of the natives. It pays a coffee planter to take up a tract of primeval moist forest on our mountain slopes for a few years; he gets bumper crops the third, fourth and fifth years, but denudation of the soil and erosion goes on rapidly, and it does not pay him to keep it up many years.

Two other examples may be mentioned. In Ajmere-Merwara in Rajputana, all the waste and forest land was handed over to the people by government in 1850. The hills were rapidly denuded of timber and grazing was uncontrolled. The crops are irrigated from tanks (ponds) formed by building embankments across ravines. Some of these were very old. The rainfall is scanty and comes in heavy showers. The water, rushing down in torrents, quickly eroded the denuded hillsides, the tanks filled up with silt and debris or the embankments burst. In 1869, at the end of a two-year famine, the region was described as follows: "The cattle had perished, the people fled, large villages were entirely deserted and the country was almost depopulated." All this was due to the mistaken policy of giving to the people what they had clamored for, the uncontrolled use of the forest lands. An even more classic example is that of the well-known Hosiarpur Chos in the Punjab. These hills were formerly fairly well wooded. A rapid increase in population followed the advent of British administration in 1846. The consumption of forest produce augmented, the herds of grazing cattle multiplied excessively, and complete denudation ensued. This was followed by erosion, broad stretches of sand invading the plains beneath, with the result that the arable lands of 940 once prosperous villages were covered with sand, which laid waste upwards of 70,000 acres of fertile lands. In 1900 this formerly rich district was traversed by numerous broad, parallel, sandy belts cut out of the crop-bearing and fertile area.

In India these matters are now well understood, and the forest department, supported by the government, has control of the great forest areas. Proofs of the disadvantages and disasters following the uncontrolled wasteful utilization of the forests in mountainous and hilly country are not therefore wanting. It is known that the same processes are at work, and the same mistakes are being made, in our Colonies. It is the habit of British administrations to work in water-tight compartments. Probably the major portion of the difficulties being experienced in different parts of the Empire have been solved, or are approaching solution, in one or other of the provinces in India. They present no new features, as some appear to think, as the above-quoted examples go to prove. The chief difficulty is that action is delayed until almost irretrievable damage has been done and then the forester is asked to reafforest the areas so denuded. This entails an enormous expenditure, great skill, with success ever hanging in the balance.

Attention was directed to this subject at the meeting of the British Association in Edinburgh in 1920, when a paper dealing with the Indian forests was read. Resolutions of the same kind were also passed by the World's Forestry Congress held at Rome in May, 1926. As an outcome of last year's meeting of the British Association at Oxford, the chairman of the Forestry Sub-section, Lord Clinton, drew up for the council a brief statement dealing with the destruction of forests on hill slopes, with special reference to the tropical forests of the Empire. This memorandum has been submitted to the Secretary of State for the Colonies, by whom it is being communicated to the Colonies and Protectorates. It may be hoped, therefore, that the chief factors of destruction, namely, shifting cultiva-

tion, excessive grazing and the firing of forest lands, may receive that measure of considered control which the expert forestry services under the Colonial Office are fully capable of inaugurating if supported by the several administrations.

[H. L. L.]

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## Safety First and Last in the Power Plant\*

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BY F. G. WHITNEY

*Superintendent, Hartford Electric Light Company, Hartford, Conn.*

When you stop to consider that each year about ninety thousand people die in this country as the result of accidents, and about two million more are injured, you can readily see how important it is to train and drill every man in your employ to be always on guard to avoid injury to himself and his fellow workmen.

I do not know what proportion of the total number killed or injured every year work in power stations, but I do know from my own experience that a great many men are hurt in power plants every day. Most of these injuries are of a minor nature and if skilled first aid is given immediately, cause no further trouble.

Whether these injuries are great or small, most of them are avoidable. Unceasing vigilance and persistent training—these and these alone—will keep down the toll of accidents.

Men doing the same work day after day don't think, or take a chance, or are in a hurry to finish a certain job, when off goes a finger or leg, or out goes an eye. There is a hurried trip to the hospital and maybe in a few days the men will all chip in to buy flowers for poor Bill.

Modern power plants are very safe as far as the apparatus is concerned, and so are the older plants. Where safety appliances once were lacking, these have been installed so that the old plants are often quite as safe as the newer stations. The fact is that there are not many more safety devices that can be installed on machinery; machines of most types are now about as safe as they can be made. If any appreciable reduction is to be made in this annual toll of life and limb, it must be done by education. This education, to be complete, has got to start with the man in charge and go right down through the whole organization to the tool boy. Great stress should be laid on safety at the foremen's conferences, once a month at least, until they know that it's up to them to reduce the number of accidents to a minimum.

A safety committee composed of men from the various departments is a very good way to get the men interested. This committee should be changed every three months, so as to get all the men acquainted and familiar with safety. What one group of men doesn't see or think of, another group may. It is also

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\* From *National Safety News* for February, 1927.

a good thing for the man in charge to talk with the various groups, and have outsiders who may be interested in this movement talk with them, pointing out what is being done in other places to avoid accidents.

Committee or no committee, the foremen must be the main stand-by; they are the ones who must be instructed and drilled to carry out the greater part of this work. They are with the men most of the time and have direct charge of the various jobs, so it is up to them to see that the men take no unnecessary risks in their work.

I rather think that accidents to the eyes are the most numerous. Men do not like to wear goggles, but they are about the best eye protectors we have. They do get hot and covered with dust, but it is much easier to wipe off the goggles than it is to go through life with a glass eye. The goggles should be worn when chipping, using the emery wheel or doing anything where there is the least possibility of getting anything in the eye that might injure it.

#### MAKE IT A HABIT

Boards or planks lying on the floor with nails sticking up through them caused thousands of men to lose a foot or a leg or maybe life itself. Make it a practice to pick up or pile all boards taken from boxes or concrete forms so that it will be impossible to step on them.

Broken or wobbly ladders are responsible for many broken legs and arms, as well as more serious accidents. When a ladder gets in this condition, throw it in the furnace, or destroy it in some manner.

Old material lying promiscuously around the plant is very often an excuse for calling in the family doctor. Old steel beams, boards, broken bricks and other junk may cause someone to have a sprained ankle or fractured shin, if nothing worse.

Twisted or warped planks used in staging are likely to dump someone in the sump. When used for higher scaffolding, they may result in a broken back or neck, and maybe several of them. Planks so twisted should never be used except for firewood.

#### UNGUARDED OPENINGS

Some of the most serious accidents have been caused by leaving temporary openings in the floor unguarded for just a few minutes; someone happens along and down through the hole he goes. If that hole had been guarded with a rope or wooden rail or covered with planks, the ambulance would not have been called. It is the rankest kind of carelessness to leave an opening unguarded, even for a minute.

Of course all permanent openings or stairways should be guarded with strong handrails. Sometimes these handrails get loose or broken and in that condition are worse than none. When John tries to rest by leaning against the rail, he goes to a place where he can have a permanent rest and no handrails are needed.

Flywheels, gears, belts and any moving machinery where a man can get caught should be protected in such a way that it is impossible to get into them. Hand-rails may do; where they are not sufficient make guards of heavy steel wire fencing.

Most elevators are equipped with safety gates, but not all. Those so equipped are all right when the gates work; when they don't they should receive attention before some one falls down the shaft. Those not having safety gates should have some automatic device for protecting the shaft when the elevator is not at that floor. The other automatic appliances on elevators get out of order from time to time.

Poor lighting is another cause of numerous and varied injuries, all the way from stubbing your toe and biting your tongue to falling down stairs and breaking your neck or somebody else's. There is almost no excuse for not having proper light; one serious accident will cost more than all the necessary lights would amount to in several years. Stairways and all openings should be especially well lighted, the lights so located that they cannot shine in one's eye when going down stairs.

#### EMERGENCY LIGHTS

Emergency lights should be provided and installed at such places as need general illumination, as well as at stairways and other dangerous places. These lights should be connected to a separate storage battery or the control-switch battery, and should be tested every day to make certain that the automatic emergency switch is working properly and that no lights are burned out. In addition to the emergency circuits just mentioned, oil lamps should be set at all necessary and important places and lighted every day before dark.

Fuses and all automatic electrical devices for opening circuits should be inclosed or protected in such a way that when they blow or open, there will be no possibility of anyone getting burned. All wiring should be protected in the same way; many a man has taken a ride in the hurry-up wagon because wires were run in a careless manner or the insulation was poor.

Traveling cranes, like all other machines, have to be looked after. They need oiling or greasing; the cables or chains should have frequent attention, and occasionally a new part is needed. A good safe ladder is required to reach most cranes, and should be provided; the practice of walking along the crane track to go to or from the crane should not be allowed.

No man should be allowed on a crane unless he is used to working in high places and has good eyesight. Once in a while an operator gets rambunctious and thinks he is driving his flivver along some speedway, until he strikes the end of the building, maybe wrecking the crane as well as himself or someone else. Overloading cranes is bad practice, and generally unnecessary; you know the capacity of the crane and the load to be lifted. If it is too heavy, don't take a chance unless it is absolutely necessary. At least make certain that no one gets under the crane while it is overloaded.

Rigging of all kinds should be kept in good condition. When a rope is stranded, don't use it. If necessary to use it, cut out the stranded part and have a new splice made. The sheaves in blocks need oiling to keep them safe as well as easy to use. When moving heavy pieces on rollers, see that no one gets his foot under the rollers; it may slow up the job and incidentally smash the foot.

Chain falls may get you into trouble, if they are not kept in the pink of condition. When they get strained, they should be sent to the shop for overhauling before they are used again.

Badly worn tools are dangerous things to have around. Monkey wrenches, Stillson wrenches and open-end wrenches that are strained and sprung should be sent to the junk pile; they have a bad habit of slipping when in a tight place and may let Jim take a header to the basement floor, or hit Tony a crack in the jaw, making him swallow a few teeth, if nothing more. Cold chisels that are tempered too hard or whose heads are all flattened out, may snap off and fly into Bill's eye, doing more harm than he can repair in a month, or several of them. Worn hammers, with split handles, can also cause a lot of grief.

It is not necessary to use tools like these, the company doesn't want you to use them. You can rest assured that when tools like I have just described are used, and someone gets hurt, the powers that be will pin no medals on you for trying to economize.

Skylights or other glass in roofs of buildings must come in for regular inspection and regular maintenance to avoid the possibility of a painful and maybe serious accident. A one-inch wire screen under the skylight will catch any glass that may fall out.

Pipes are often run so low that it is impossible to pass under them without either stooping or hitting them. It's all right to stoop when there is plenty of time and the light is good, but when the lighting is poor or a man is in a hurry, he may not think to stoop. Where pipes are low enough to bump the head or low enough to be tripped over, they should be protected so that a man can not bump into them in the dark.

#### SAFETY DEVICES FOR GAGE GLASSES

Bursting gage glasses on boilers or receivers have given many a man nasty cuts and burns. There are several safety devices on the market to prevent such accidents, and it is a good investment to install them, if these gage glasses are low enough to fly and hit someone when they burst.

Safety valves have a bad habit of blowing when someone is in range of the business side of them; if a man does not happen to get burned he is lucky, but the chances are he will be badly scared. Lead the discharge side of the valve up through the roof, if possible; if not, lead it up high enough so it is over a man's head.

#### PROTECTION AGAINST DUST

When it is necessary for a man to work where it is very dusty—and there are a number of such places in power stations—he should always cover his face, or nose and mouth, with cheese cloth or some other protection, to keep the dust

from going into his lungs. The gas mask is better than the cloth, especially, if there is any possibility of gas. It is true that most men don't like to wear gas masks, but a little persuasion will help. After the first shock is over they will get used to them and there will be little further trouble. Gas masks should be worn when cleaning condensers, especially where there is much sewage in the condensing water.

I could write a book on the number of men who have been hurt, and some of them very seriously, as a result of horse play, but I'm not going to—not at this time. I'll wait and see if you habitual kidders and fellows that like to put up jobs on the other fellow cut out your nonsense before I write it. But at any rate, boys, cut it out; there is nothing in it. I went through the mill and I know.

Flammable materials such as oils, paints, varnish, gasoline, etc., should always be placed where there is no possibility of fire. The fire risk itself is bad enough, but there is the danger of an explosion, and of someone being injured. Gasoline and kerosene tanks should be buried underground. The other things mentioned should be kept in a fireproof room with smoking or lighted matches absolutely barred.

Another hazard is the empty oil barrel, which, like the empty gun, has sent many a man to the hospital. The barrel is empty—at any rate Joe thinks it is—but to make sure he lights a match so he can see the bottom of the barrel. It is needless to say that the barrel is empty long before Joe reaches the hospital. If it is necessary to look in, use an electric light, and ventilate the barrel before being too inquisitive. All empty barrels that have contained volatile material should be classed as dangerous.

There is not an accident described here that I have not seen, and some of them many times. A little vigilance on the part of the men or foremen would have prevented most, if not all of these accidents.

[W.M. E. S.]

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## Zeolite Formation in Soils\*

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BY P. S. BURGESS AND W. T. McGEORGE

*A new line of attack for investigating soil fertility problems has developed following the discovery of the silicate compounds in soils known as zeolites. The leading investigators of soil problems declare these compounds to be fundamentally associated with most chemical and physical properties of soils. This line of investigation promises to throw considerable light upon the interactions which have occurred between the salts contained in irrigation water and the soils to which the water has been applied. Studies of the replaceable bases in the soils of infertile areas, in central Maui, have been carried on by Dr. F. E. Hance for the past eight months. Similar work will be undertaken shortly by W. T. McGeorge on certain Oahu soils.—G. R. S.*

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\* A contribution from the Arizona Agricultural Experiment Station, Tucson, printed in *Science* 64:652-653, 1926.

The presence, in soils, of zeolites (basic hydrated aluminum silicates) possessing the property of base replacement, has been known and studied by chemists for a great many years. The source or origin of these chemical compounds is unknown, although most authorities, either by direct statement or by intimation, have given us the idea that, as they make up an important part of the clay fraction of soils, they are chiefly formed by the slow natural processes of decomposition, hydration and trituration under water, over long periods of time and are of great age.\*

During the researches being conducted in this laboratory upon the aluminates and silicates occurring in alkali soils, the following question arose: Having shown that black alkali soils contain sodium aluminate and sodium silicate in the soil solution, and having found that these two compounds will unite in the cold to form sodium zeolite, may we not consider such a union possible within the soil complex under natural conditions? The present paper constitutes a brief summary of detailed work which shows to our satisfaction that the zeolites now present in soils have not necessarily existed for untold ages but may be of very recent origin—in fact, may even now be in process of formation.

In preparing a synthetic zeolite by the above method, namely, from solutions of sodium aluminate and sodium silicate in the cold, the resulting colloid was found to possess extremely active base replacement properties. Also, upon adding small amounts of solutions of the above compounds to soils and allowing the latter to dry in the air at room temperatures we obtained a notable increase in their zeolitic content as indicated by quantitative base replacement studies. We have thus built up the zeolite content of a soil by adding the two compounds which we had previously shown would combine to form a zeolite, and which two compounds we have also shown to be present and to be often in process of formation within black alkali soils.

On mixing concentrated solutions of sodium aluminate and sodium silicate the resulting solution will almost instantly solidify to a gel. Dilute solutions, N/50 for example, showed no gel formation even on long standing. By titrating such a dilute solution with acid, however, it was found that zeolite formation occurred and, in dilute solution, is a function of reaction. Continuing this line of experimentation, we found that at strongly acid or strongly alkaline reactions a high concentration (due to high solubility) is essential to the formation of the colloidal zeolitic gel, while in dilute solutions the components combine within a definite pH range only. The maximum precipitate, or range of lowest solubility, is on the acid side of neutrality, pH 5 to 7. At pH 3.6 the zeolite was completely soluble. Our results to date indicate that it is far less soluble in alkaline than in acid solutions, although it has an appreciable solubility in both.

We thus obtained data in the above titrations showing that zeolites are completely soluble in dilute acids.† On titrating back with alkali, however, the colloid

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\* Gedroiz claims that more recent "secondary absorbing complexes" in the form of "absorption compounds" may be formed by the union of particles of colloidal silicic acid carrying negative charges with those of colloidal aluminum hydroxide carrying positive charges, but that such "new formations" are extremely unstable, "decomposing easily into their constituent parts."

† This would confirm the results obtained by Kelley, Gedroiz and others who have shown that in attempts to use acids as a carrier of H ions in base replacement there is a disruption of the zeolite molecule.

was again formed and its typical base replacement property restored. To prove that the colloidal zeolite molecule had been broken down into its acidic constituents (silicic acid, aluminum chloride and sodium chloride) an acid solution of the zeolite was dialyzed through a paraloidion membrane, the dialyzed solution neutralized to a reaction of pH 6.0, and evaporated until a gel was again formed. This zeolite gel had reacquired its base replacement property.

After having formed the basic zeolite from its alkaline constituents, which we have shown to be present in black alkali soils, the acid zeolite was then synthesized from the acid constituents which are known to be present in acid soils. These are silicic acid and soluble aluminum and sodium\* salts (chlorides). The physical and chemical properties of all of these zeolites are being studied and their formulae determined.

The next step in our investigations was to extract the components of the zeolites from both alkaline and acid soils and cause them to recombine to again produce zeolites. Thus, a soil was leached with 3 per cent hydrochloric acid, the leachings evaporated upon the water bath to a gel, and this gel shown to possess the property of base replacement. A similar experiment using water or a solution of sodium hydroxide was carried out with a black alkali soil, with the same typical property of base replacement showing in the colloid obtained. In the latter case there may not be a destruction of the zeolite molecule during extraction, as the leachings from a black alkali soil will often contain sufficient soluble aluminates and silicates to recombine under proper reaction conditions to form the insoluble zeolite with replaceable base properties, without evaporation. As stated above, our work shows that the zeolite molecule is most stable under alkaline conditions. This is doubtless due to the excess OH ion present, which prevents hydrolysis. It is also very stable in the presence of an excess of the common metallic ion.

This work indicates that there is a great similarity between the soil zeolites as prepared either from acid or alkaline soils (acid extracts of the former and both water and alkaline extracts of the latter), and those artificially prepared on the one hand from aluminum chloride, silicic acid and sodium chloride, and on the other from an alkaline aluminate and silicate. In fact, we are inclined to consider them as practically identical.

The small amounts of soluble aluminum present in acid soils probably result from the solution, with accompanying decomposition, of previously formed zeolites which are slightly soluble at hydrogen ion concentrations below pH 5.0.

It is a widely known fact that black alkali (sodium carbonate) may be formed by the interaction between calcium carbonate and either sodium sulfate or sodium chloride. It may also be formed by the natural weathering of basaltic rocks. We are inclined to attribute the formation of zeolites in alkaline soils to the presence of black alkali formed as above (with attendant high pH), rather than consider black alkali as usually derived from sodium-zeolite hydrolysis. This latter explanation of black alkali formation appears to us to be putting the cart before the horse, for the major trend of chemical reactions in soils will be in the direction of synthesis of the least soluble product, which here, most assuredly, is the zeolite.

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\* Soluble potassium, calcium or magnesium salts may be used.

That sodium hydroxide may be formed by the hydrolysis of sodium zeolite, after the latter has been formed, is of course well known, but the importance of this reaction in black alkali formation in soils is open to question.

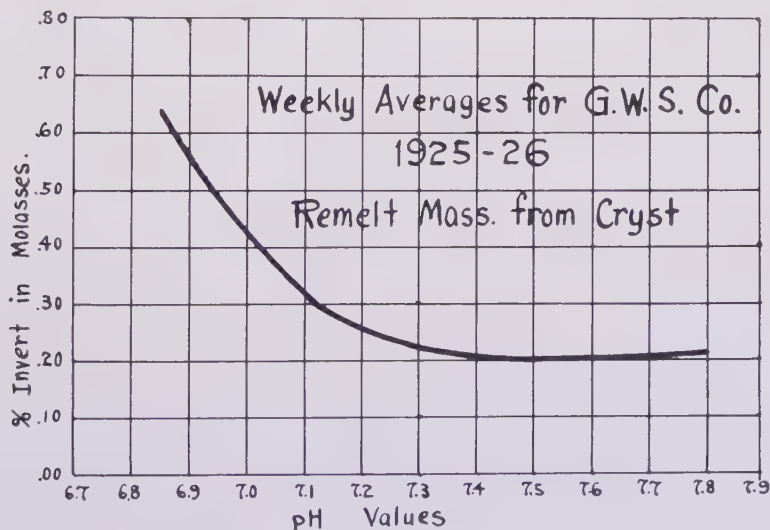
To recapitulate briefly, our work thus far indicates that the steps in zeolite formation in alkaline soils are somewhat as follows: Sodium carbonate is formed from the interaction between white alkali and calcium carbonate; the sodium carbonate hydrolyzes to give sodium hydroxide\*, which ionizes to produce a solution of high alkalinity (pH 10 to 11.5); sodium silicate and sodium aluminate are formed under these conditions from the more readily soluble aluminum silicate minerals; as the pH is lowered, due to washing out by rains or irrigation, or as the soil dries out, the sodium silicate and sodium aluminate combine to form sodium zeolite, which may remain as such or be converted into other zeolites, depending upon the salt concentrations within the soil solution.

A detailed account of this work soon will appear in the technical bulletin series of this experiment station.

## pH and Inversion in Beet Sugar Factories†

By J. H. ZISCH

It is planned eventually to put the factory control of the Great Western Sugar Company's plants on a pH basis, from blow-ups to sugar end, but at present this basis is applied chiefly to the last products. The author considers it probable that the lowest pH at which it is best to carry blow-up thick juice and both raw



\* In dilute solutions (N/20 or less), sodium carbonate is hydrolyzed to the extent of 65 per cent or more.

† In *Sugar Press*, Vol. 10 (1926), No. 6, pp. 16-17.

and white massecuite is exactly 7.0, but until more comprehensive data on the subject are available it may be advisable not to allow the pH to go below 7.2. Some work on the subject was done at several of the factories during the past campaign, and the accompanying curve shows the danger of inversion of sugar when the pH of massecuites is allowed to drop below 7.0 to 7.2. A pH of 6.8 to 6.9 results in the inversion of about three times as much sugar as is found with a pH of 7.2.

The phenomenal run during the last campaign at the Greeley factory (winner of the annual Great Western Sugar Company pennant race) is ascribed to the application of pH values in the control of the sugar end. Several weeks' averages showed alkalinities of from —.040 to —.070 for raw massecuites with practically no inversion, or at least nothing abnormal; this was equivalent to a pH value around 7.0.

In the curve, pH values as abscissae are plotted against per cent invert sugar in the molasses.

[W. L. McC.]

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## Effect of Cane Tops on Sugar Recovery\*

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By W. SCOTT

The following experiments illustrate the loss caused by the delivery to the mill of improperly topped canes:

Canes with green tops were selected from trucks in the factory yard; the tops (including green cabbage and white joints) were cut off at the base of the sheath. Canes and tops were ground in a laboratory cane mill and analyzed separately. The analysis of the whole cane, as given below, was calculated from these separate analyses (average of three tests):

	Tops only	Topped canes	Whole canes
Sucrose per cent.....	4.17	12.71	11.65
Juice—Brix .....	12.23	18.20	17.50
Sucrose .....	5.43	15.38	14.39
Purity .....	44.39	84.50	82.22
Weight per cent.....	11.84	88.16	100.00

A lower sucrose extraction was obtained from the tops than from the remaining portion of the cane. Allowing for this, but otherwise using figures representing normal factory conditions, it was found that the tonnage of cane required to produce a ton of sugar worked out as follows:

Canes free from tops, 8.72 tons.

Canes with tops, 10.34 tons.

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\* From *Trop. Agr.* 3:235, 1926.

The tops representing 11.84 per cent of the weight of the cane, were responsible for an increase of 18.42 per cent in the tonnage of cane required to produce a given quantity of sugar. . \*

It is therefore evident that the tops, while producing no sugar, cause an appreciable loss of the available sugar contained in the richer portion of the cane.

[W. L. McC.]

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## Action of Sugar on Cement\*

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BY A. SETON

Lime dissolves in an aqueous solution of sugar to form a saccharate which is very soluble in water. It is therefore obvious that the presence of sugar in the water used for mixing, or in the cement itself, is highly deleterious. In some experiments an ordinary cement was used which gave a final settling time of  $8\frac{1}{2}$  hours when tested in the usual manner with the standard Vicat needle. When a  $7\frac{1}{2}$  per cent solution of sugar was used instead of water the final set was under 45 minutes. Briquettes were made up for the tensile test with a 20 per cent solution, and some broke on placing in water after 24 hours in the air in the moulds in a damp atmosphere. Others survived immersion, but none for more than six days. A further series kept in the air cracked after exposure for eight weeks. Briquettes made with a  $1\frac{1}{4}$  per cent solution lasted for some months, but all cracked eventually. The le Chatelier tests showed the tremendous expansion that a very small quantity of sugar will produce. The original cement had an expansion of 2.5 millimetres, which the use of a  $1\frac{1}{4}$  per cent solution of sugar increased to 15.5 millimetres. The result of such an expansion in a reinforced concrete cantilever or pile can be imagined.

The experiments led to the following conclusions: (1) the setting time of an ordinary cement is greatly reduced by the presence of sugar; (2) the tensile strength is also reduced, and immersion in water accentuates the weakness; (3) the expansion shown by the le Chatelier test becomes too large to permit the use of cement.

The work as carried out had reference to new cement only, and further investigation is necessary to determine the effect of sugar on concrete that has set. It would appear that as the free lime has become hydrated and carbonated, and to some extent has combined with the silica available, there should be very little action.

[W. L. McC.]

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\* From *Chemical Age*, 15:326, 1926.

## The Carbonatation Process in Natal\*

BY W. A. CAMPBELL

I am dividing my paper into the four following heads:

- (1) The reason for name, and basic principles of the process.
- (2) Kiln work.
- (3) Juice treatment.
- (4) Results obtained and advantages.

### NAME, AND BASIC PRINCIPLES OF THE PROCESS

In cane juice clarification, lime is almost the universal clarifying agent, but for a thorough purification, a large excess must be used, and this excess has to be removed by a neutralizer.

Carbonic acid gas has been found to be the cheapest neutralizer of excessive quantities of lime, and the most economical way of making use of lime and carbonic acid gas is by burning limestone (lime carbonate) in a lime kiln where 100 lbs. of limestone produces 56 lbs. of quick lime and 44 lbs. of carbonic acid gas.

As its name implies the carbonatation process is essentially connected with the production and use of carbonic acid for juice treatment.

By burning the limestone in a lime kiln, we separate it into its two constituent parts, that is, quick lime and carbonic acid gas. In the carbonatation of juice, we reverse the destructive work of the kiln, and combine again the carbonic acid gas to the lime in the presence of juice.

It is this formation of new soft powdered limestone in a dirty cane juice which constitutes the basic principle of the process. In doing this we change a large excess of pure lime into carbonate of lime, and the French chemists have named the process "carbonatation," and this name has clung to it, although more correctly it ought to be "carbonation."

### KILN WORK

The kiln here is the standard Belgian type and burns 40 to 50 tons of limestone a day in a continuous operation. When lit, a few days previous to starting the mill, the fire is kept alive right through the crushing season.

It is fed with limestone broken to the size of a man's fist, and coke in the proportion of 9 per cent coke to the weight of limestone. The coke is added to promote heat and also to produce an excess of  $\text{CO}_2$  (carbonatation) gas.

A lift raises the stone and coke in wagon loads to the top of the kiln, and at regular intervals charges of the mixture are dropped in by special arrangement.

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\* From a paper by the Managing Director, Natal Estates, Ltd., delivered before the Third Annual Sugar Congress, South Africa.

At regular intervals also the burnt lime is drawn away at the bottom of the kiln, so that the limestone and coke mixture is practically in a continuous slow descending motion in the kiln, whilst it is getting burnt to quick lime and ashes.

The heat of the kiln is maintained by the burning of coke, and also by the strong draught of a powerful gas pump, which regulates the burning of the kiln, and at the same time sucks the gas and delivers it to the juice side of the sugar house.

The presence of a pump intensifying the heat of a kiln and controlling its output of gas creates new conditions which do not exist in the usual lime kiln where the burning of lime is the only aim.

In our case burning of lime and gas production are of equal importance, and has to synchronise with the juice production of the factory; on that account a carbonatation lime kiln demands technical ability, and a vigilant scientific control.

The burnt quick lime is slaked and diluted to a cream in a rotary drum, which is sieved to get rid of unburnt particles, or dirt, and after cooling is ready for the juice treatment.

The carbonic acid gas sucked from the top of the kiln is cooled and scrubbed before reaching the gas pump.

The lime kiln, lime slaking and lime storage is in a separate building from the rest of the factory, and together with the gas pump constitutes a department of vital importance to a carbonatation mill, as any defect there would eventually cause crushing operations to stop.

A well balanced kiln work, which means perfectly burnt lime, and a plentiful supply of gas, is conducive to safe, easy running on the juice side to such an extent that sugar men experienced in the sulphitation process with the vagaries of that craft called "juice tempering," no longer care for this old process, and quite paradoxically, and contrary to the outsider's general opinion, call the  $\text{CO}_2$  process the simplest in existence.

## JUICE TREATMENT

The first step in juice treatment is heating raw juice from the mills to a temperature of about  $140^\circ \text{F}$ . This temperature fulfills the best conditions for gassing, filtration and color of juice.

The hot juice is sent to the gassing tanks where "carbonatation" is conducted.

Our practice is to fully open the valve connecting the gas pump to the carbonation tank, so that all the gas from the kiln is being blown into the juice, whilst a continuous stream of lime cream runs in the juice, mixes with it, and is carbonated.

The lime cream flow is regulated so that nearly all the lime is neutralized and only a small percentage left as free lime. This is checked by means of specially prepared test paper which turns pink or white according to the amount of lime neutralized.

The reason for continually neutralizing the lime instead of letting the full quantity act on the juice, and then neutralizing (as is done in beet root practice), is

that with the new method the violent frothing common to juice full of free lime, is considerably diminished.

This frothing is particularly noticeable with Uba cane juice, and in our first trials we found that the viscosity of the Uba juice was such that for the first portion of gassing the juice would not absorb the gas, and because of this we pump the raw juice from the mill to the patent tower 30 feet high.

This juice meets the exhaust gas from the tanks and gives it a pregassing. It also acts as a save-all and foam breaker.

The addition of lime in the juice with its simultaneous carbonatation is continued until the operator judges that the juice is sufficiently treated for a quick filtration.

A sample of muddy juice taken from the tanks would then show in a test tube a quickly settling mud, with a clear yellow juice on top. The real test, however, is the speed of filtration when the juice is sent to the filter press.

An experienced carbonator adds a uniform quantity of lime in each tankful, and the safest method is to add a slight excess of lime in case juice from bad cane should have been treated. The average quantity of lime used for Uba juice is about 12 per cent by volume at 15° Baume.

Other countries would naturally think this excessive, but we find by practice that it is the safest figure we can use; although I have known juices for short periods to take only 8 per cent of cream.

The action of lime on hot juice is to neutralize the natural acidity of the juice, kill the germs, and coagulate and bind various impurities inimical to sugar extraction, and this action is further helped by the formation of carbonate of lime in the juice. Added in large excesses to the viscous Uba juice, it really changes for the better the physical qualities of the refractory juice, especially by acting on the gummy substances which in other processes slime the presses, retard the boiling, and diminish the extraction of crystals.

The juice treated with the proper quantity of almost neutralized lime can now be easily filtered in filter presses, where the mud is kept as a solid cake. The lime cake contains nearly all the carbonate of lime (limestone) from the kiln together with the impurities removed from the juice, and constitutes a very valuable fertilizer.

For every ton of sugar produced, one ton of this fertilizer is sent to the fields.

Due to its porous nature this cake is easily washed free of the sugar it contains, so that in spite of the heavier quantity of cake manufactured in the CO<sub>2</sub> process, the sugar losses in scum cake are smaller than those of any sulphitation mill. The cake is washed until it contains but one-half per cent of sugar by weight of the cake. The defecation process gave us 8 to 11 per cent by weight.

The clear filtered juice containing a small amount of free lime in solution is sent to a second series of carbonatation tanks where the final neutralization is carried out.

Carbonatation, carried out in two stages, that is, double carbonatation, is safer than the single process, as it allows of rectification of mistakes at the first stage.

Whereas the first carbonatation takes an average of 10 minutes, the second one is carried out in about 1 minute, but demands a finer adjustment, as it is the final gassing.

The second  $\text{CO}_2$  juice after neutralization is heated to  $165^\circ \text{F}$ . and sent to another series of filter presses where the small residue of lime carbonate in suspension is removed.

The clear filtered neutral juice is then slightly sulphured to a quantity equivalent to a tenth of that used in sulphitation mills when juice becomes slightly bleached, a favorable condition for white sugar. It is then heated to boiling point and filtered again.

From there it is concentrated and another filtration given, after which it is boiled to grain.

#### RESULTS OBTAINED AND ADVANTAGES

1. All juice from the mills reaches the evaporator in 30 minutes. Probably 4 or 5 hours were required with the former process.
2. The mills have an uninterrupted run.
3. Due to pure juice obtained, the capacity of our boiling house and centrifugal department has increased at least 30 per cent.
4. An increased recovery of sugar. Better quality of sugar.

#### COMPARATIVE FIGURES OF SULPHITATION AND CARBONATATION MILLS IN WHITE SUGAR MANUFACTURE

1. Rise in purity from raw juice to syrup: Sulphitation, .5 to 1.5. Carbonatation, 4 to 6.
2. Gallons of molasses per ton of cane: Sulphitation, 6 to 7. Carbonatation, 4 to 5.
3. Sugar lost in molasses per cent of the sugar in the juice: 13 per cent to 14 per cent sulphitation; 8 per cent to 11 per cent carbonatation.
4. Weight of scum cake per cent cane, 3.5 to 4 sulphitation; 10 carbonatation.
5. Loss of sugar in cake per cent sugar in the juice, 3.5 per cent sulphitation; 0.5 per cent carbonatation.
6. Recovery of pure sugar in bags, per cent of the sugar in the juice, 73 per cent to 77 per cent sulphitation; 83 per cent to 84 per cent carbonatation.

[W. L. McC.]

## The Most Important Loss in the Manufacture of Sugar from the Java Canes\*

BY WILLIAM E. CROSS, PH.D.,

*Director, Sugar Experiment Station, Tucuman, Argentina*

In the manufacture of sugar from the Java canes P. O. J. 36 and 213, there is a source of loss which does not figure in the factory reports, but which nevertheless produces very serious losses, affecting both the factory and the cane grower, and producing enormous differences in their annual balances, in some cases even converting gains into losses. We refer to the loss produced by not grinding freshly cut cane, owing to the deterioration which results between the cutting and the milling.

When other perishable products like milk, vegetables, etc., are concerned, the farmer never allows several days to pass before taking his products to market; but the cane grower, whose product is equally perishable, frequently allows himself the luxury of a considerable delay in delivering his cane to the factory, perhaps not realizing the great losses produced in this way.

This Experiment Station called attention to this peculiarity of the Java varieties so far back as 1914†, and since that time has frequently insisted on this matter, without having been able to convince more than a part of the cane growers and factory owners in Tucuman of the absolute necessity of grinding these canes within one or two days of cutting.

That some *ingenios* still grind a good part of their cane in a deteriorated condition, we know from our own observations, as well as from conversations with superintendents of factories, and from many factory reports. We know some factories, for example, whose annual reports indicate a high Brix in the normal juice, for instance 18 or 19 per cent, with a purity of little more than 70 per cent, this being an indication of an exaggerated case of having ground old deteriorated cane instead of fresh cane, and indicating also a loss of several tenths of 1 per cent in the yield of sugar per cent cane obtained in the factory, as well as several hundreds of dollars—lost by the growers who supplied the factory with the cane.

Seeing that the degree of deterioration which the cane suffers after cutting depends on climatic conditions, it is impossible to establish an exact relation between the number of days which pass between cutting and milling, and the damage which the cane suffers; but, taking the average weather conditions of the crop in this country, we may arrive at figures which are very significant. The data which we will proceed to give are based on results obtained in the experiments of this Station‡.

\* Circular 16, Agricultural Experiment Station, Tucuman.

† *Revista Industrial y Agrícola de Tucuman*, 1914, 5, 277-290.

‡ *Idem*, 1916, 7, 219-250.

## LOSSES FOR THE CANE GROWER

Immediately after cutting, the cane begins to suffer a loss in weight, for which reason even the grower who sells his cane without reference to its sugar content suffers a definite loss every day that passes between the cutting and the delivery of the cane to the mill. This loss results on an average between 1 and 2 per cent of the weight per day. This means to say that the grower, who is accustomed to deliver his cane during the crop some 5 days after cutting, loses on the average between 100 and 200 lbs. on each ton. Or in other words, the grower who produces 10,000 tons of cane does not deliver more than 9,500 or even 9,000 tons to the factory, which implies a loss of several thousand dollars a year.

It will be seen that this loss is of sufficient importance to warrant a serious effort to avoid it. It is true that by keeping the cut cane well covered with trash the loss can be limited to some extent, and in cases where the delivery of the cane has to be delayed for reasons beyond the control of the grower, this procedure should always be followed; seeing, however, that this method does not eliminate the loss, but simply reduces it, it can only be considered an emergency measure for occasional cases.

If the grower sells his cane on the sugar content basis, in delaying the delivery of the cut cane he not only suffers from the loss in weight, but also from the reduction in sugar content that the cane suffers, of which we will speak in the next paragraph.

## LOSSES FOR THE FACTORY OWNER

If the loss in weight which is produced by the drying-out of the cane were not accompanied by chemical changes in the juice itself, there might be a certain advantage to the factory in receiving from the grower cane that had been cut some days, as the growers and cane cutters would be paid for a less weight of richer cane. But, unfortunately, there occurs an alteration in the sucrose content of the cane, which takes place simultaneously with the loss in weight, if not, indeed, even more rapidly. As the cut cane begins to "invert," the sucrose becomes converted into uncrystallizable products. This inversion is due to an enzyme produced in the cane, principally after it is cut, which increases in proportion day by day, producing a correspondingly greater degree of inversion from one day to another. In this way the rate of the inversion process increases in a kind of arithmetical progression, the amount of sucrose lost on the 6th day, for example, being much greater than that inverted during the third day. For this reason, probably, during the first few hours after cutting (the number depending on the climatic conditions) the cane does not suffer any inversion at all. But the enzyme soon begins to form, and to produce the inversion for which it is responsible.

It may be said that under Tucuman conditions, cane which is left more than 48 hours after cutting incurs a very serious risk of loss of sucrose by inversion, and that after this interval the cane suffers, on the average, a daily loss of between 1 and 3 per cent of its purity, according to the weather conditions.

The loss produced by this inversion is much more serious than would appear at first sight. In the first place, not only have we a loss in sucrose, but the sugar

that remains in the juice is proportionately less available than it was. To explain this point we might take an example. A certain cane at the moment of cutting had the following composition (of the juice):

	Per cent		Per cent
Brix .....	14.6	Glucose .....	9.6
Sucrose .....	11.8	Purity .....	80.8

Of this sucrose, 90.5 per cent was available. Three days later the cane had lost 6.3 per cent of its weight, and the analysis of its juice was as follows:

	Per cent		Per cent
Brix .....	15.6	Glucose .....	1.0
Sucrose .....	11.9	Purity .....	76.3

Taking into account the loss in weight, the net loss of sucrose was 0.65 per cent, and of the sucrose that remained in the juice only 87.7 per cent was available.

Besides the actual loss of sucrose produced by the inversion, and the lower availability of that left in the juice, the damage done to the cane is increased by the harmful effect of the substances produced by the deterioration, as the inversion of the sucrose is accompanied by other chemical changes in the juice. The substances referred to seriously affect the manufacturing processes, the juices of "inverted" cane being more difficult to clarify and filter, and the syrups more difficult to boil, than with freshly cut cane. More time is required for the several operations of the manufacturing process. For this reason the factory which works on the basis of cane cut some days suffers losses much greater than those indicated by the simple analysis of the cane, and also finds that its daily capacity is reduced and that its cost of production per pound of sugar is increased.

The cane grower who sells his cane to the factory for a percentage of the sugar which it yields suffers a double loss if he delivers cane cut some days: the loss in weight, and the loss produced by the inversion. That is to say, the weight of the cane received by the factory is less than it was when it was cut, and the yield of sugar it produces is less than it would have produced if it had been milled without delay after cutting.

#### HOW THESE LOSSES CAN BE PREVENTED

The losses produced by milling deteriorated cane are of such magnitude that even the most heroic measures are justified to prevent them. Some factories and growers have taken the necessary steps, but others have confined their efforts to trying to hurry up deliveries without modifying their organization, etc., in such a way as really to solve the problem. It is clear that the matter deserves the special attention of the managers of these factories, who ought to make radical changes in their methods of harvesting and delivering the cane in order to meet the case.

For example, in many parts the harvesting of the cane is done by men working individually, and paid by the weighed cartload. Before a cart can be loaded the man himself must cut enough to fill it, which takes him between two and three days. The greater part of this cane is thus more than 24 hours old when the cart is loaded, and some of it much older. If the cane is cut by gangs of workmen

on the other hand, the loading can proceed parallel with the cutting, in such a way that the cane is loaded within a very short time of being cut. It is our opinion that in all cases of cane taken to the mill in carts, it can be made to reach the factory within 24 hours of cutting.

When the cane has to be transported by rail, we admit that the problem of quick deliveries is a more difficult one, as it is true that in many cases serious delays are produced due to lack of wagons, or because the cane is moved slowly even after the wagons are loaded. But we think this is due in part to the fact that the railway authorities have not realized as yet the fact that the peculiarity of the Java cane to "invert" rapidly after cutting necessitates that it should be treated with the same preference as milk, vegetables, etc., the Java cane being in this sense very distinct from the old purple and striped varieties which were formerly planted here. It should be the function of the cane growers and factory owners and their unions and associations to educate the railway authorities and employees regarding this matter, in the hope that once they realize the perishable nature of these varieties of cane they will treat them accordingly, hastening their transport in every possible way.

As the transport of cane by rail implies a delay which is up to a certain point inevitable, it is especially important to be sure that this cane does not suffer any further delay in being loaded into the railway wagons, and later before being ground once it reaches the factory. If, as we have said, the cane taken to the factory in carts requires to be loaded the same day as cut, this is all the more necessary in the case of cane to be transported by rail. Nevertheless this is a point which is not always properly realized. We know of cases, for example, where the cane is loaded on to the railway wagons 4 or more days after cutting. We had to investigate a case in which the cane transported by rail to the factory always arrived in a very deteriorated condition. We were able to show that the rail transport required 3 days on the average, but that the cane was only loaded on the railroad wagons some 5 days after cutting. Thus with better organization regarding the deliveries of cane to the rail head, the loss through inversion suffered by this cane could have been reduced by much more than half. We wish to emphasize this point, as we have found that in some factories it is customary to lay the blame for the bad condition of the cane on the rail transport without taking the necessary steps to prevent the avoidable delays in delivery to the railway wagons.

Seeing that with the system of loading in vogue in this country, chain slings are used for handling the cane, delays are sometimes produced by the fact that the growers have not received promptly from the factory the chains they need for loading. It is in the interests of the factory itself to organize its work in such a way that delays for this reason will be reduced to the lowest possible limit.

Even though for lack of wagons, or other reason, fortuitous delays are occasionally produced, the inversion suffered by the cane can be reduced to a great extent by employing the measures indicated by this Experiment Station some ten years ago. At that time we showed that the cut cane placed in piles and carefully covered with trash suffers less than that exposed to the air, and that if this cane can be kept in a moistened condition, by throwing water over the piles of cane several times a day, the inversion can be reduced to a veritable minimum.

In some cases the cane which is several days in transport by rail might be drenched with water by a hose or other means at several points on the journey; the organization of this practice would cost very little in comparison with the benefits it would produce. And in the case of a breakdown in the factory, the cane should not be left in the fields, but should be accumulated in the factory yard, where the piles should be drenched with water two or three times a day at little expense.

In conclusion, we will repeat a recommendation which was also made by us several years ago. In our investigations, to which we have referred, we were able to show that the rate of deterioration after cutting varies very much with the variety of cane, some varieties suffering comparatively little in this respect, in contrast to the P. O. J. 36 and 213 which are among the canes that invert most rapidly. If therefore because of the distance of his plantations from the factory or for other reasons, a grower knows that his cane will always have to suffer a considerable delay between cutting and milling, he should not cultivate these rapidly inverting varieties, but rather those which we have shown to invert only slowly even after being cut many days; such, for example, as P. O. J. 2725, P. O. J. 228, D 1135, and the old purple and striped canes, the first mentioned of which we consider the best under ordinary conditions.

[W. L. McC.]

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## Seedling Propagation and Selection in Java\*

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*In a recent publication from the Experiment Station at Pasoeroean, Dr. J. P. Bannier, the botanist at that Station, describes in considerable detail the methods of crossing, seedling propagation and selection which are now being followed in Java. A review of the paper, which has been translated through the kindness of Mr. W. van H. Duker, is presented in the following pages.—A. J. M.*

### SELECTION OF PARENT VARIETIES FOR CROSSING

In addition to the varieties and combinations which have been found in the past to produce good seedlings, new varieties and new combinations are added each year to the crossing program. As far as possible all varieties available are tried out as parents; inferior canes possessing certain desirable qualities as well as the highly productive varieties are included. It has been found that crosses between two superior varieties often produce inferior offspring, and that desirable seedlings may be obtained from parents which are themselves inferior.

It is desirable to cross both good and poor varieties with a number of others to determine, so far as possible, the qualities which a given variety tends to transmit to its offspring.

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\* From *De Rietveredeling aan het Suikerproefstation te Pasoeroean*; Techniek, Richeitng en Resultaten van 1893-1925. Archief voor de Suikerindustrie in Nederlandsch-Indie, Jaargang 1926, No. 19.

## PREPARATIONS FOR THE CROSSING CAMPAIGNS

## A. Observations on Tasseling.

The tasseling season in Java usually lasts from the middle of March to the end of May.

The first move at the beginning of the crossing season is to determine which varieties may be expected to tassel.

The first sign of tasseling is the so-called "boenting" stage, in which each new leaf blade becomes shorter than its predecessor while its sheath becomes longer.

The second stage is marked by the appearance of the flag.

The third stage begins with the appearance of the tip of the tassel.

The fourth stage is marked by the opening of the first flowers, indicated by the extrusion of the stigmas and anthers.

The dates of appearance of these four stages are recorded each year. These records, if kept over a period of years, may be expected to supply information as to the influences exerted by outside circumstances on the time of tasseling of the different varieties.

The time of tasseling of a given variety may vary considerably in different years, depending upon time of planting, soil and rainfall.

In the crossing work at Pasoeroean this difficulty was met with: the breeding canes Glagah (*Saccharum spontaneum*), Kassoer\* and many Kassoer descendants tassel several weeks earlier than the best sugar producing varieties, so that it is difficult to cross the two groups. An attempt was made to hasten the flowering of the late varieties by earlier planting, but with poor success.

A solution of the difficulty was found by transferring the crossing work to the Malang Plateau. Here the tasseling periods of the two groups overlap more than at Pasoeroean. Here also certain varieties continue to produce tassels for six weeks to two months and many varieties tassel profusely which do not tassel at all at Pasoeroean.

This difference is thought to be due to the difference in climate. Pasoeroean is low, warm and dry, with a mean annual temperature of 79° F. and a rainfall of 52 inches. The crossing garden on the Malang Plateau has an altitude of 1200 feet, a mean annual temperature of 75° F., and a rainfall of 94 inches. Varieties such as Lahaina, Badila and Uba tassel heavily at Malang, and never at Pasoeroean†.

## B. Determination of Fertility of Flowers.

A second activity preliminary to the actual crossing is that of determining the quality of pollen of the different varieties.

The genus *Saccharum* is hermaphroditic, that is, the flowers normally produce both pollen and egg cells. There are, however, many varieties in which the pollen is nearly or entirely sterile, which may be used as females without castration. This is fortunate, since emasculation by hand is so laborious as to be impracticable.

\* This cane has recently been introduced for breeding purposes and is now growing on the Station grounds here at Honolulu. It has little sugar but is extremely hardy, and has been found in Java to be an excellent parent.

† Altitude appears to have the reverse effect in these Islands. The difference may be due to the fact that they are about 12° farther from the equator.

The quality of the pollen is determined as follows: Tassels of the varieties to be examined are collected early in the morning before the beginning of pollen shedding, and are brought to the laboratory. Pollen shedding begins at about six and continues usually throughout the forenoon. The pollen is allowed to fall upon glazed blue or black paper. When a sufficient amount has been collected it is placed upon a glass slide and stained with iodine in potassium iodide. The well developed pollen grains are large and round; they contain starch and take a bluish stain, while abortive, shrivelled grains remain yellow. The percentage of functional grains is then estimated or determined by counting.

Those varieties in which a large proportion of the anthers shed their pollen normally, and in which a large percentage of the grains are well developed are used as male parents, while those producing little or no good pollen are used as female parents.

#### CROSSING METHODS

Four different methods of crossing are used: first, crossing in the open; second, bagging; third, "live" crossing, and fourth, the application of pollen by hand.

##### 1. *Crossing in the Open.*

In former years most of the crossing was done under bags, but at present the so-called "open" method is most widely used. Shortly before blooming the female stalk is tied to a bamboo pole. When the blooming begins a bamboo container filled with water is tied to the pole, and in it are placed two male tassels which are tied in such a way as to permit their pollen to fall directly upon the stigmas of the female tassel.

Since the cut tassels do not remain fresh more than 20 to 24 hours the male tassels must be changed daily. The best tassels for this purpose are those in which the blooming has proceeded a little more than half way down the tassel. In these a maximum number of flowers may be expected to open the next morning.

The time during which the male tassels may be changed is limited. The flowers open shortly before sunrise and a little later, between 6:00 and 7:00 a. m., pollen shedding begins. The shedding continues through the early part of the morning. During this period the air in a tasseling field is full of pollen grains and, inasmuch as the surrounding male tassels protect the female to a certain extent against foreign pollen, it would be undesirable to remove them as long as pollen shedding is in progress. It has usually ceased by 3:00 or 4:00 p. m. The male tassels are therefore changed in the morning before sunrise, or after 4:00 in the afternoon.

The duration in days of the blooming period of a female tassel, and therefore the number of times that the male tassel must be changed, ranges from four to ten—most frequently it is six or seven. It varies with the variety and with external conditions. In the cool moist climate of the Malang Plateau the blooming period is shorter than in the warm lowlands of Pasoeroean.

This method of crossing usually yields a good percentage of viable seed, although it varies, of course, with the fertility of each of the parents.

## 2. *Bagging.*

The percentage of viable seed obtained from this method is much smaller than from crosses in the open. It is therefore used only in scientific studies, where absolute certainty as to the parentage is essential.

The male tassels are placed in a bamboo container and are tied in position as in the "open" method. The pole, however, is in this case provided with a cross-piece from which is suspended a bag made of gauze, which completely encloses both male and female tassels. The male tassels must be changed daily, as before. The method is laborious, and, as stated, usually yields relatively little viable seed.

## 3. *"Live" crossing.*

In this method both the male and female tassels remain standing, and are bent toward each other and tied in such a position that the pollen of the male will fall on the stigmas of the female.

This method has the advantage that only one tassel is required for pollinating the female, but it has the disadvantage that to be used extensively it requires the planting of a special crossing plot. Even when this is done there is the chance that one of the two parents may fail to tassel. The method is only used when suitable male and female tassels happen to be near each other. No special plantings are made for the purpose.

## 4. *Hand Pollination.*

This method is regularly practiced at the end of the season when tassels are scarce. The pollen is collected from the male tassel on dark blue or black glazed paper, carried to the female tassel and applied by rubbing the latter gently over the glazed paper on which the pollen rests, or by means of a brush.

Of the four methods described the first is the prevalent one. The last three are used only in special cases.

# RIPENING OF THE SEED

As soon as the female tassel has finished blooming the last male tassels are removed and the female tassel is covered with a bag of mosquito netting, which serves as a protection against birds, against blowing away of the ripe fuzz, and against contamination by wind-blown fuzz from other tassels.

The length of the ripening season depends upon the variety and upon the locality. It is of longer duration at Malang than at Pasoeroean. The average, however, is about three to four weeks.

The separating of seed from the tassel and the drying of the flag are taken as indications of ripeness.

When ripe the tassel is cut and hung to dry for a few days in a place protected from rain, but exposed to light and air. When dry the individual seeds separate readily from the tassel. They may now be collected for sowing.

# SOWING

This is done in wooden trays about 20 inches square and 6 inches deep, having a few holes in the bottom for drainage. The trays are filled with fertile soil

consisting of a mixture of 1 part fine sifted soil (tarapan), 1 part sand and 1 part manure. Before mixing, the soil is exposed to the heat of the sun which tends to kill any weed seeds which may be present.

To prevent the fuzz from being blown away during the process of sowing the tray is placed under a cage of wire and cotton cloth provided with an opening through which the fuzz may be introduced. The fuzz is spread into a thin layer, well pressed down and moistened with a fine spray. It is finally covered with a very thin layer of soil.

The seed trays are exposed to the sun as much as possible, except between 11:00 a. m. and 3:00 p. m., when they are shaded to avoid burning. They are also protected during heavy rains by a light rainproof roof. During the first few days after sowing, or until germination begins, the trays are covered with muslin. They must be watered with a fine spray at least twice a day. Any weeds which may come up are eliminated at regular intervals.

#### GERMINATION

The fuzz germinates very quickly, usually two to three days after sowing. If after ten days no seedlings have appeared the seed tray may be discarded since no germination is likely to occur thereafter.

Some crosses yield much more fertile seed than others, consequently the number of seedlings per tray varies greatly. Some trays will yield only 5 or 10 seedlings while others contain thousands.

When the young plants are still very small they are often attacked by damping-off fungus which quickly destroys many of them. As soon as it is discovered the unharmed plants may be saved by removing them with a little clump of soil about an inch in diameter and planting them out in other seed trays. Spraying with pyoctanin solution is also sometimes successful in controlling damping-off.

#### TRANSPLANTING

When they are three to four weeks old the young seedlings may be transplanted into pots. Flower pots about five inches in diameter are used. They are filled with the same soil mixture as the seed trays; this mixture is as a rule rich enough so that no extra fertilization is required. A small hole is made in the loose soil with the finger or with a stick—it must be deep enough so that the roots can hang down freely. After transplanting the plants are well watered.

The work is done in a covered transplanting shed where the plants remain for about two days. By this time they have become sufficiently well established to withstand full sunlight, and they are placed in the open. They are watered at least twice a day, weeded regularly and the soil kept loose to facilitate the entrance of air. If the transplanting is carefully done the number of plants which die in the process is small.

Only 150 to 200 seedlings are saved from a single flat. The number which can be handled is limited by the available facilities and it is believed that the

chances of obtaining superior seedlings are greater when a relatively smaller number of seedlings is grown from each of a large number of combinations, than when a large number is derived from a single type of cross.

The young plants remain in the pots for about two months. At the end of this time they are about a foot high, and the root system is so well developed that it fills the pot; stooling is also well along.

#### PLANTING IN THE FIELD

The seedling fields are laid out according to the Reynosa system of irrigation as universally practiced in Java. The seedlings are spaced about  $3\frac{1}{2}$  by 4 feet. The further treatment of the seedlings is the same as that for plantation cane, except that they are not so heavily fertilized. With the lighter fertilization the poor growers may be more quickly detected.

It is the practice to select as seedling fields those in which the soil is below the average. Seedlings with a poor root system may do well on good light soils and fail completely on heavy soils. It has been found that a greater percentage of selections made on poor heavy soils are likely to thrive under all kinds of circumstances than when the selection is made on good light soils.

#### SELECTION

##### A. *Time of Selection.*

Formerly an attempt was made to exercise a certain amount of selection in the seedling trays. It is now believed, however, that this is a dangerous practice, since especially in crosses involving *Saccharum spontaneum* and Kassoer, rapid growth is often associated with sponginess and low rendement.

The present practice is to make the selections after tasseling is over, in May and June, when the seedlings are about a year old.

##### B. *Manner of Selection.*

The requirements which a seedling must meet if it is to survive the first selection are becoming more severe each year. It is the policy to retain only a very small percentage so that those retained may be the more intensively studied.

The following table shows the percentage of each year's sowings from 1911 to 1925, which were retained after the first selection:\*

1911.....	15.36%	1919.....	1.57%
1912.....	6.71	1920.....	1.06
1913.....	17.11	1921.....	.83
1914.....	3.28	1922.....	1.42
1915.....	.69	1923.....	.73
1916.....	4.25	1924.....	.60
1917.....	1.44	1925.....	.30
1918.....	1.20		

\* It is doubtful whether such severe elimination the first year can be safely practiced in these Islands, where the ability to carry over and to ratoon are important factors.

### C. *Basis of Selection.*

The principal characteristics upon which selection is based are the following:

#### 1. Length of Stalk.

The longest stalks are usually selected—those which are too short are immediately eliminated. To be retained a seedling which tassels must have a longer stalk than one which does not, since the weight per unit of length of the latter is usually greater than that of the former.

#### 2. Diameter of Stalk.

This quality must be judged in connection with the number of stalks. Plants with a large number of thin stalks may yield as much as those with a smaller number of heavy stalks; there is, however, a minimum which cannot be exceeded. There is no maximum, but experience has shown that very thick stalks are as a rule not so desirable as one with stalks a little thinner. Very thick stalks few in number means too great a loss when a stalk is injured or broken. Besides, very large canes are often spongy or hollow, sometimes very brittle, with poor juices.

#### 3. Conformation of Stalk.

Stalks which maintain their diameter well toward the top are to be desired. Stalks with straight and regular nodes are preferred to those with zigzag nodes.

#### 4. Growth Habit.

A perfectly vertical habit of growth is preferred to a slightly inclined position since in the latter case the danger of lying down is great.\* Any seedling showing a tendency to recline, especially with limited fertilization, is rejected.

#### 5. Internodes.

Long internodes are usually a very desirable quality. Excessive length may be objectionable, however, especially in thin canes. The nodes contribute more to the strength of the stalk than do the internodes. Prominent, bulging nodes are undesirable. Plants with many growth cracks are discarded.

#### 6. Behavior of the Root Eyes on the Root Band.

In many seedlings the root eyes show a tendency to develop. Such seedlings are immediately discarded.

#### 7. Conformation of the Eyes.

Some seedlings have protuberant eyes. Such eyes are liable to damage when seed is shipped, and this is therefore an undesirable quality.

#### 8. Lalas.

Early or excessive lala-ing is undesirable.

#### 9. Stooling Out.

This character cannot be as definitely determined in the seedling stool as in stools growing from seed pieces. Therefore seedlings with but two or three stalks need not necessarily be discarded. Excessive stooling may also be objectionable.

#### 10. Position, Shape and Color of Leaves.

Since the growth of the plant depends largely on the quantity of chlorophyl-

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\* The climate of Java is such that any tendency toward recumbency is undesirable.

bearing tissue a wide leaf is better than a narrow one. Since sunlight which strikes the leaf perpendicularly causes greater assimilation than that which strikes at an angle, drooping or overhanging leaves have an advantage over those carried in a steep, erect position. Furthermore, an overhanging leaf closes in better and thus utilizes the light to better advantage. In general, dark green color is preferable to yellowish-green or light green.

#### 11. Self-stripping.

A prompt shedding of the old leaves is a desirable quality. Adhering leaf sheaths make harvesting difficult. Furthermore, they shelter pests and retain water, which encourages rotting and sprouting of the root eyes.

#### 12. Tasseling.

Excessive tasseling is an undesirable quality. There are some heavy tasseling varieties which suffer very little, but some plant food is inevitably extracted from the stem for the formation of the tassel. Other things being equal, non-tasseling seedlings are preferable to those which tassel. Tasseling can only be tolerated if the sponginess associated with it does not extend much below the tassel. Late tasseling is less objectionable than early tasseling.

#### 13. Uniformity in Size of Stalks.

Like stooling ability, this quality cannot be accurately judged in the seedling stool. However, seedlings showing great variation in size of stalk should not be kept.

All of the qualities mentioned above are observed on the standing stool. Seedlings which are satisfactory with respect to these qualities are given a number beginning each year with No. 1, prefixed by a letter reserved for that year. Thus 1924=N, 1925=O and 1926=P. To illustrate, the 1284 plants selected in 1925 from the 1924 sowings received the numbers N 1 to N 1284.

After the field selection is finished and the plants sufficiently ripened (in July) the selected plants are dug up, roots and all, and brought to the selection room for the so-called mill selection. In the selection room the sticks are separated, and roots, dirt and leaf crown are removed and measured. A second selection on the basis of visible characters is made at this point. Comparisons between plants are easier to make here than in the field and usually quite a number are discarded.

After this selection the sticks are cut in two, and the tops, about one-third of the entire length, are saved to be used for seed if the juice and other internal characters are satisfactory.

Plants with dry, spongy or hollow pith are discarded. Perfectly solid sticks are most desirable.

All plants which remain after this selection are ground in a sample mill and the Brix and polarization determined. Growth conditions of the year in question are taken into consideration in determining the standard. In a year of high average rendements, for example, it is better to place the standard higher. The basis of selection therefore varies more or less, but at Pasoeroean, a Brix of 18 with a polariscope reading of 65 (sucrose 15.8, purity 87.8) is considered the

lower limit. Anything below this is discarded. The juice analyses, however, are always judged in connection with the habit of growth and other characters and many seedlings with good juices must be condemned. While not an absolute rule it frequently happens that the best looking seedlings have the poorest juices.

The top seed pieces of the plants which have survived the final selection are now planted in two or three rows. The number of seed pieces is, of course, limited, and the quality is sometimes poor on account of tasseling, so that it is often difficult to obtain a good stand. It may be necessary to resort to very wide spacing. These things must be taken into consideration in the second year's selection.

A few seed pieces of each of the very best plants are planted in a suitable place for spreading. These very best selections, seldom more than five in a family, are called "maximalists." As soon as the shoots of these plants are large enough to form roots of their own, usually in about  $2\frac{1}{2}$  months, they are removed and planted elsewhere—when these in turn have produced shoots large enough for replanting, the process, which is called "seblangen," is repeated. If a variety "seblangs" well the method permits of very rapid spreading. The ability to "seblang" has also been found to be a very good criterion of the vigor of growth and the root forming power of a seedling.

#### SECOND SELECTION YEAR

Selection in the second year is less difficult because 10 to 20 plants of each variety are now available. It is easier to determine whether a given quality occurs generally or whether it is sporadic. The stooling and tasseling characteristics can also be much more accurately determined the second year.

Notes are taken throughout the second year. Two or three months after planting the germination and stooling ability are recorded. A short time previous to tasseling, in February, further notes are taken of the habit of growth and the character of the top. The third and last examination of growth habit is made after the tasseling season in May, and a further selection is made, the elimination being based on the same characters as in the first year. At this time ten average stalks of each variety are labeled, an analysis of the juice of five of them made immediately, and of the other five in July, to give information as to the earliness or lateness of ripening. At this time the external and internal qualities of the sticks are again examined. The number retained after the second year seldom exceeds 25 per cent of those selected the first year. Juice analyses are made on all seedlings before elimination, however, to obtain information as to the relation to each other of the analyses for the two years.

The varieties retained after the second selection are now planted in a larger plot of 2 to 10 rows. In recent years the rows have been divided into halves, one of which is given a light and the other a heavy fertilization, in the hope that in this way some information might be obtained as to how the seedling reacts to favorable and unfavorable conditions. Thus far, however, the results have not been very definite.

If at the end of the second year a seedling should appear so superior as to give promise of outclassing the existing varieties, as much seed is planted as possible in order to supply those plantations who wish to have it. In this way the extension of new varieties proceeds very rapidly. Thus of P. O. J. 2878 there was in 1922 one mature plant; in 1925, 3062 acres; and in 1926, 43,750 acres.

### THIRD SELECTION YEAR

The selection in the third year is carried on in the same manner as in the second year but on a still more rigid basis. Seedlings surviving this selection are given P. O. J. numbers and are sent to plantations for field trials. The suitability of a seedling to a given soil type and its value as compared with the variety already being grown can only be determined by field trials in the area in question. The results of many years, however, have shown that the relative value in the selection plots checks with the relative value in field practice. The best seedling of a certain family in the selection plot is usually best also in field practice.

The P. O. J. series includes all seedlings grown at the Experiment Station, seed of which has been sent to plantations.

### AIM AND POLICY OF THE CANE IMPROVEMENT PROGRAM AT PASOEROEAN

The incentive to cane improvement may be traced back to the failure some fifty years ago of Black Cheribon\*, the standard variety, which began at that time to display pronounced susceptibility to the sereh disease. A search was therefore begun for varieties resistant to sereh which would yield as well as Black Cheribon. The different varieties of the Malay Archipelago were tried out first but they were either too low in yield or not sufficiently resistant. As soon as the possibility of sexual propagation of sugar cane was established this method was at once adopted with the object of finding a variety which might replace Black Cheribon. The history of the first attempts to obtain and germinate cane seed has already been related by Kobus† and Wilbrink and Ledeboer‡.

The aim throughout has been to obtain varieties which give a reasonable yield and which at the same time are resistant to sereh and yellow stripe. The first attempts in this direction met with little success, but it seems that in recent years this goal has been reached.

### THE POLICY OF CANE IMPROVEMENT FROM 1893 UP TO THE PRESENT TIME

The first seedlings were produced in 1893. At that time field crosses were employed. P. O. J. 100 was obtained among these first seedlings. It was a

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\* Louisiana Purple.

† J. D. Kobus. Historisch overzicht van het zaaien van suikerriet. Archief, 1893, pp. 14-29.

‡ G. Wilbrink en F. Ledeboer. De geslachtelijke voortplanting bij het suikerriet. Archief, 1911, I, p. 367.

seedling of Bandjarmasin hitam (Rose Bamboo) crossed with Loethers. The work was under the direction of Wakker, at that time director of the Experiment Station.

In 1894 no new seedlings were grown. In 1895 and 1896, seedlings were again obtained mainly from field crosses. These two years did not yield any valuable varieties. Indeed, it would have been an unusual coincidence if anything especially good had resulted from the methods employed. In a crossing plot where many varieties are brought together and allowed to cross at random, the chance is small that pollen from the best male parent should happen to fertilize the best female parent.

To obtain a variety like P. O. J. 100 from this method is a very unusual occurrence.

#### THE CHUNNEE NOBILIZATION

In 1897, Kobus introduced a new method of attack. He obtained from British India, 18 different varieties which were temporarily placed in quarantine at Banka. In 1896, the best of these, Chunnee and Ruckree, were brought to Pasoeroean. These varieties have very thin sticks. However, they are extremely hard, produce fairly large stools and have a good rendement. They belong to the type designated by Jeswiet as *Saccharum barberi*.

In 1897, Kobus began crossing Chunnee with the large sticked noble canes. The process of crossing the thin sticked varieties with the large sticked noble canes will be referred to hereafter as "nobilization." Chunnee produces pollen, therefore it must be used as the male parent. Striped Preanger (Striped Mexican) was used as the female parent in that year.

In 1898 and 1899, Chunnee was crossed with Black Cheribon (Louisiana Purple). In later years other varieties were crossed with Chunnee, but up to 1912 the Chunnee-Black Cheribon crosses were the most numerous. A few crosses wherein Chunnee did not participate were made, but on the whole the period from 1897 to 1910 may be designated as a period of Chunnee nobilization.

During this period not only was Chunnee crossed with noble canes, but the descendants of these crosses were again crossed with the noble canes. The resulting seedlings were designated as "derived" or "twice nobilized" Chunnees.

Among the seedlings produced as a result of crosses between Chunnee and the noble canes are P. O. J. 36, 213 and 979. The principal properties of these and other Chunnee descendants are medium thickness, medium rendement, a tendency towards hollowness of the pith, resistance to sereh, strong root system, and therefore resistance to unfavorable conditions, high susceptibility to yellow stripe and a tendency to lie down. While they are able to compete fairly well on very bad soils none of them was outstandingly superior and they were never extensively planted.

In the years following 1905 attempts were made to obtain superior varieties by crossing together the best of the Chunnee hybrids. A number of seedlings which showed distinct improvements over the first generation of Chunnee descend-

ants were obtained in this way. They retained, however, their susceptibility to yellow stripe and none of them became very important as commercial varieties.

Thus, the Chunnee nobilization program yielded no very important results. Since 1914 Chunnee has entered less and less into the crossing program and at the present time it is no longer used in crossing work. Chunnee descendants, however, are occasionally used in combination with Kassoer and with Kassoer descendants.

#### IMPROVEMENT WORK WITH THE NOBLE VARIETIES

After the abandonment of the Chunnee nobilization program in 1912 and before the Kassoer nobilization program was begun, special attention was paid for several years to crosses among the noble canes themselves. Several varieties with good growth were obtained, especially from crosses between Fiji and Green German New Guinea. In general, however, those varieties having a good rendement were too susceptible to sereh and to yellow stripe to be of use. In recent years crosses between the noble canes have been conducted mainly with the object of studying the inheritance of their properties rather than with the hope of obtaining commercially important canes.

#### THE KASSOER NOBILIZATION CAMPAIGN

Kassoer was used in crosses with the noble canes as early as 1893 and especially in 1902, 1907, 1908 and 1909. However, the offspring of these crosses were not desirable as commercial canes because of their low rendements.

After the discovery that Kassoer was in reality a hybrid between one of the noble canes and a wild cane, Glagah\* (*Saccharum spontaneum*), it was realized that the first generation of Kassoer hybrids was still too closely related to their Glagah grandparent, which produces no sugar, to give a good rendement. However, when these twice nobilized Glagahs were again crossed with the noble canes the rendement of the offspring was considerably improved. Furthermore, they usually retained their resistance to sereh, along with a strong root system and a vigorous growth. At the present time most of the work at Pasoeroean is conducted with thrice nobilized Glagah descendants. P. O. J. 2364†, which results from a cross between P. O. J. 100 and Kassoer, proved to be one of the best of the twice nobilized Glagahs. It has a very good growth habit, long straight joints, fairly large sticks, a strong root system and great vigor. The rendement is also very good as compared to that of other varieties of the same parentage. The fact that it transmits its good qualities to its offspring makes it especially valuable for crossing work. In fact, it has proved to be the best of the first generation of Kassoer hybrids for breeding purposes. It has been crossed with a

\* Glagah (*Saccharum spontaneum*) is a wild cane with little sugar and thin sticks, but quite resistant to disease.

† This variety is now in quarantine in Honolulu.

number of male parents. Thus far, crosses with E. K. 28\* have given the best results. The seedlings resulting from such crosses are characterized by vigorous growth, strong root system and partial or complete resistance to the principal cane diseases. They also have a fair rendement.

The thrice nobilized Glagahs have again been crossed with the noble canes. This fourth nobilization has yielded seedlings with better rendement than those of the third nobilization, but the resistance to diseases is somewhat less. In addition to noble canes with a high rendement it has been found desirable to use for the fourth nobilization noble canes which are as highly disease-resistant as possible, even though their rendement may be somewhat inferior.

#### NOBILIZATION OF *SACCHARUM SINENSE*

For several years a number of crosses were made with different varieties belonging to the species *Saccharum sinense* which includes Tek-cha, Puri, Uba, Swinga, Kavangire\* (Porto Rico Uba) and Cayana\*. The yield of these varieties is rather low but they have a fairly good rendement, a strong root system and resistance to sereh. The resistance to yellow stripe varies in different varieties, but is certainly less pronounced than was formerly believed. Many of these varieties transmit their undesirable qualities strongly to their descendants. Kavan-gerie has proved to be the most desirable for crossing purposes. In general, the nobilization of *Saccharum sinense* has not yielded important results.

#### THE INHERITANCE OF CHARACTERS

Because of the complex hybridity of sugar cane very little is known concerning the nature of the inheritance of specific qualities.

A mistaken conception which one sometimes encounters is the following: If one of the grandparents of a variety is Glagah and the other three grandparents are noble canes it is assumed that the variety is one-fourth Glagah and three-fourths noble. This, however, is incorrect. Due to the fact that the formation of egg cells and pollen grains the characters received from the two parents are distributed entirely at random, it may happen that such a variety may receive either much more or much less than one-fourth of its inheritance from the Glagah grandparent.

The offspring of all varieties is variable. It has been observed, however, that on the whole one variety tends to transmit certain qualities, another variety other qualities.

From the observations of many years, it is possible to draw certain conclusions as to the qualities which some of the better known varieties are likely to transmit when used in crosses. A few of the varieties and the qualities which they tend to transmit are listed below:

P. O. J. 2364\*. An exceptionally large number of crosses have been made with this variety during the last ten years. It transmits almost all of its good

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\* This variety is now in quarantine in Honolulu.

characters to its offspring. Its fuzz usually gives a low percentage of germination as compared with other varieties. The characters which it transmits to its offspring are the following: medium diameter, good length, strong root system and good rendement. Weaknesses of P. O. J. 2364 offspring are a strong tendency to tassel and sometimes sponginess. These characters must be strongly selected against. As male parents in combination with this variety as the female E. K. 28\* and S. W. 111 have up to the present proven best.

P. O. J. 2725\*. This variety produces seedlings freely, but they are of mediocre quality. Their principal weaknesses are coarseness, heavy tasseling, medium to poor rendement, prominent eyes and lala-ing.

D. I. 52\*. This variety usually produces but little fertile pollen and it has not given especially good results as a female parent. In recent years it has been found to give pollen fairly freely on the Malang Plateau, and while the results of crosses when it is used as a male are still scanty, it has been observed that the good rendement of D. I. 52 has been transmitted to various of its offspring, and that their growth habit is also fairly good.

E. K. 28\*. Of the male parents which have been extensively used, E. K. 28 is one of the best. The fertility of the pollen is often rather poor, especially in the lowlands. It transmits its good growth habit to its offspring, which also usually have a good rendement. One of the weaknesses of E. K. 28 is its heavy tasseling, which it transmits to many of its offspring. It usually transmits also its quality of late ripening.

S. W. 3\*. This variety is well suited for crossing with varieties having large sticks, because its small sticks are transmitted to many of its offspring. The stalks of its offspring are often variable in size and are sometimes inclined to be soft, although their growth habit is fairly good, their length satisfactory, and their rendement fair.

Bandjarmasin hitam (Rose Bamboo). This variety rarely tassels at Pasoeroean and the fertility of its pollen is poor. At Malang it tassels more freely, and the fertility of its pollen at the beginning of the season is fairly good, though very poor later on. By virtue of this fact this variety may be used both as male and female parent. The size of stick is very often transmitted to its offspring. They frequently inherit, also, its good rendement. Their growth habit, however, is coarse, the eyes often protruding and in many the pith is dry. Germinations from crosses with this variety are usually few.

Preangerriet (Striped Mexican). The pollen fertility of this variety is about the same as that of Rose Bamboo. The percentage of germination is usually small. The rendement of its offspring varies greatly, but is often quite high. This variety transmits its good characters to its offspring to a greater extent than many others.

Black Cheribon (Louisiana Purple). This variety was extensively used in former years, especially with Chunnee and with Chunnee hybrids. Since the characters of the latter are strongly dominant, little is known as to the qualities which it transmits to its offspring. But little fertile pollen or none at all is pro-

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\* Now in quarantine at Honolulu.

duced on the lowlands, but at higher altitudes with lower temperatures and higher humidity and especially at the beginning of the season the pollen fertility may be fairly high. The growth habit of its offspring is fairly good, their rendement likewise. On the whole, however, this variety is considered inferior to Striped Mexican for crossing purposes.

Lahaina. This variety is highly esteemed as a female parent in crosses. It tassels rather scantily in the warm lowlands, but more frequently in the cooler and moister regions. It has a strong tendency to transmit its high rendement to its offspring, but associated with it is a weak root system and susceptibility to mosaic. Many of its offspring have large sticks, but they are often coarse or weak. The nodes are often short and poorly shaped, and the root eyes frequently show a tendency to sprout. On account of its high rendement, however, Lahaina remains an important variety in the crossing program.

*(In addition to the above varieties the author discusses also the breeding qualities of many not found on these Islands.)*

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## Sugar Prices

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### 96° Centrifugals for the Period December 16, 1926, to March 15, 1927

Date	Per Pound	Per Ton	Remarks
Dec. 16, 1926.....	5.08¢	\$101.60	Cubás.
“ 22.....	5.05	101.00	Cubás.
“ 29.....	5.065	101.30	Cubás, 5.08; Porto Ricos, 5.05.
“ 31.....	5.15	103.00	Cubás.
Jan. 3, 1927.....	5.21	104.20	Cubás.
“ 5.....	5.165	103.30	Cubás, 5.18, 5.15.
“ 7.....	5.12	102.40	Cubás.
“ 12.....	5.05	101.00	Cubás, 5.08, 5.02.
“ 14.....	5.005	100.10	Cubás, 5.02, 4.99.
“ 17.....	4.96	99.20	Cubás.
“ 19.....	4.915	98.30	Porto Ricos, 4.90; Cubás, 4.93.
“ 20.....	5.02	100.40	Porto Ricos.
“ 24.....	4.90	98.00	Porto Ricos.
“ 26.....	4.93	98.60	Cubás.
“ 27.....	4.99	99.80	Porto Ricos, 4.96; Cubás, 5.02.
“ 28.....	4.90	98.00	Cubás.
Feb. 1.....	4.89	97.80	Porto Ricos, 4.91, 4.86; Cubás, 4.90.
“ 3.....	4.83	96.60	Porto Ricos.
“ 5.....	4.96	99.20	Porto Ricos.
“ 8.....	4.90	98.00	Porto Ricos.
“ 9.....	4.945	98.90	Porto Ricos, 4.93, 4.96.
“ 16.....	4.90	98.00	Cubás.
“ 23.....	4.945	98.90	Porto Ricos, 4.93, 4.96.
“ 28.....	4.90	98.00	Cubás.
March 8.....	4.915	98.30	Porto Ricos, 4.93; Philippines, 4.90.
“ 12.....	4.86	97.20	Porto Ricos.
“ 14.....	4.83	96.60	Cubás.
“ 15.....	4.77	95.40	Porto Ricos, Philippines.

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